Dominion

May 21, 2002

Thomas A. Faha
DEQ – Northern Regional Office
13901 Crown Court
Woodbridge, VA 22193

Dear Mr. Faha:

In accordance with the post 316(a) monitoring agreement, enclosed for your review is the latest Annual Report for Lake Anna and the Lower North Anna River including a review for the period 1998-2000. The data indicate that Lake Anna and the Lower North Anna River continue to support a well-balanced ecological community and both remain some of the finest recreational resources in Virginia.

Please let me know if you have any questions concerning this information as well as any other ongoing environmental monitoring for North Anna Power Station.

Sincerely,

C. C. Taylor
Director – Electric Environmental Services

cc: w/enclosure
Mr. John Odenkirk
Virginia Department of Game and Inland Fisheries
1320 Belman Road
Fredericksburg, VA 22401

cjb527/word/sjh

ENVIRONMENTAL STUDY OF LAKE ANNA

AND THE LOWER NORTH ANNA RIVER

ANNUAL REPORT FOR 2000

INCLUDING SUMMARY FOR 1998-2000

Prepared by:

ENVIRONMENTAL BIOLOGY

ELECTRIC ENVIRONMENTAL SERVICES

In an effort to conserve our natural resources, this report is being printed on both sides of recycled paper.

TABLE OF CONTENTS

PAGE

Executive Summary

Following the successful completion of the North Anna Power Station 316(a) Demonstration in 1986, Dominion (the Company) agreed to continue selected environmental monitoring studies on Lake Anna and the North Anna River. Correspondent with the recommendations in the three-year review of post-316(a) studies for 1989-1991, the Company requested and was granted a reduction in certain of the monitoring programs by the Department of Environmental Quality (DEQ). The revised annual study program was to be continued with a review every three years for possible revisions or changes. This report represents findings from monitoring programs conducted during 2000, the third year of the three year study period and a review of the 1998-2000 data.

Station generation for 2000 was again outstanding with levels reaching the highest yearly average for capacity since 1978 when the station began commercial operation. Water temperature and fish community data for 2000 both in the lake and downstream were similar to historical data. For example, numbers of fish collected in lake electrofishing surveys in 2000 were similar to 1999 and within the historical ranges. It was theorized that low lake levels in 1998 concentrated bluegill sunfish Lepomis macrochirus at several sample sites resulting in the relatively large numbers of fish collected that year. The sampling for 2000 occurred at or near normal lake level. Numbers of fish collected by gill netting in 2000 were higher than in 1999 but similar to historical data. In 2000, Lake Anna anglers reported 72 citation largemouth bass Micropterus salmoides (greater than 55.9 cm in length or 3.6 kg in weight) ranking Lake Anna as the third best trophy bass lake in the state.

The 2000 hydrilla Hydrilla verticillata survey indicated a decrease in acreage both in the lake and Waste Heat Treatment Facility (WHTF) when compared to 1999 totals. Further, hydrilla in both the lake and WHTF was represented by plants 10 to 20 cm in length with limited vertical shoots and minimal biomass.

In the lower North Anna River, the total number of fish collected by electrofishing in 2000 decreased relative to 1999 at all four sampling stations and were in the lower range of totals reported for the period 1981-2000, most likely due to a missed survey in September of 2000. Underwater observations of largemouth bass and smallmouth bass in 2000 again showed largemouth bass to be more abundant in the upper reaches of the river below Lake Anna with smallmouth bass more abundant in the lower reaches.

In summary, the data indicate that the lake and river downstream of the lake continue to support diverse and healthy fisheries.

List of Figures

List of Figures (cont.)

List of Tables

List of Tables (cont.)

1.0 Introduction

In 1972, the North Anna River was impounded to create Lake Anna, a 3885 hectare (9600 acres) reservoir (lake) that provides condenser cooling water for the North Anna Power Station (NAPS). Adjacent to Lake Anna is a 1376 hectare (3400 acre) Waste Heat Treatment Facility (WHTF) that receives the cooling water and transfers excess heat from the water to the atmosphere before discharging into the lake.

Aquatic monitoring studies have been conducted on Lake Anna since its inception. In January, 1984, the Company initiated an extensive Section 316(a) demonstration study (P.L. 95-500) to determine if proposed effluent limitations on thermal discharges from the power station were more stringent than necessary to assure the protection and propagation of a balanced, indigenous community of shellfish, fish and wildlife in Lake Anna and the lower North Anna River. The final report (Virginia Power 316(a) Report 1986) successfully demonstrated that the operation of the power station had not resulted in appreciable harm to the biological community. The Virginia Water Control Board (VWCB) accepted the study as a successful demonstration in September, 1986.

Subsequent to the 316(a) study, the Company committed with the VWCB to continue environmental monitoring on Lake Anna and the lower North Anna River as part of a post 316(a) agreement. Also, following each three year period of data collection, a summary report is provided with recommendations for future studies. This report presents the findings for calendar year 2000, and a review of the three year period 1998-2000.

2.0 Station Operation

North Anna Power Station (NAPS) operated at an average of 94% of capacity for 2000. This represents the highest yearly average for the station since it began commercial operation in 1978. The station operated at 84% and 91% of capacity for the first quarter and second quarter respectively and 100% for the third and fourth quarter. The Station's Unit 1 was shutdown in March for a scheduled refueling outage after completing a record run of 522 days on line. This outage resulted in the lower capacity during the first and second quarter. There were two other short station outages during this period (Table 2.0-1). An average of 91% capacity for the period 1998-2000 represents the highest three year percentage since the station began operation allowing NAPS to continue as an industry leader in low cost generation.

3.0 Lake Anna

3.1 Temperature

Methods

Lake water temperature data in 2000 were collected using continuous monitors (fixed temperature recorders) and instantaneous field surveys. Continuous temperatures were measured using Endeco model 1144SSM and Onset Optical Stowaway temperature recorders which measure and record the water temperature at one hour intervals at seven (7) stations in the lake and three (3) stations in the WHTF. These instruments were located one meter below the lake surface at the stations depicted in Figure 3.1-1, the lone exception being

Station NALST10. The instrument at this station was located at a depth of three meters to account for the turbulence associated with mixing. A summary of the data recorded by these instruments for 2000 is presented in Table 3.1-1 as monthly means of daily high, mean and low temperatures.

The instantaneous temperatures were measured using a Yellow Springs Model 3000 T-L-C field temperature instrument. Temperatures were measured quarterly at one (1) meter intervals, surface to bottom, at the stations shown in Table 3.1-2.

Results

The maximum monthly mean of daily high temperatures recorded for the lake in 2000 by continuous monitors was 29.8°C in July at Station NALBRPTT which is located at mid-lake (Table 3.1-1). The lowest monthly mean of daily low temperature recorded was 4.4°C in December at Station NAL719NT which is located on the Pamunkey arm of the upper lake. These 2000 high and low temperatures as well as the rest of the monthly temperature data in Table 3.1-1 are within the ranges of data reported in previous years.

The instantaneous temperature surveys were conducted quarterly to provide temperature data to assess seasonal thermal stratification patterns in the lake. Temperatures recorded in the third quarter and fourth quarter showed little stratification (Table 3.1-2). During these surveys, surface to bottom temperature differences rarely exceed 2°C in the middle and upper reaches of Lake Anna. The July survey results show a thermocline at the 9 to 10 meter depth in the lower lake which was not present in the more shallow, upper portion of the lake. This stratification pattern in the lake is not unusual and is similar to previously reported patterns (Virginia Power 1986-1999).

Temperatures recorded in the upper, middle and lower portions of the lake for the three year period 1998-2000 were similar in both range and seasonal pattern. This is demonstrated graphically for Station NAP719ST, an upper lake location on the North Anna Arm; NAL208T, a mid-lake station; and Station NALT10, located in the lower lake at Dike 3; in Figures 3.1-3, 3.1-4 and 3.1-5, respectively. These seasonal patterns for temperature in Lake Anna are consistent with previously reported data (Virginia Power, 1997).

3.2 Fish Population Studies - Gill Netting

Methods

The monitoring of fish assemblage abundance and species composition for Lake Anna and the WHTF continued in 2000 using the same basic sampling technologies applied since 1972. Experimental gill netting was used to capture fishes which normally inhabit the deeper strata of the lake, or exhibit a diel movement to and from the shoreline. Similar to previous years, 2000 gill net surveys were conducted during February, May, August, and October at the stations shown in Figure 3.2-1. Experimental gill nets were set near littoral drop-off areas with procedures remaining unchanged since 1972. Fish collected by gill netting were returned to the laboratory where all individuals were measured to the nearest millimeter total length and weighed to the nearest 0.1 gram. Surface water temperature (°C), dissolved oxygen (mg/l), pH and conductivity (Φmhos) were recorded at the time of each sample collection (Table 3.2-1).

Results

Sixteen (16) species of fish representing seven (7) families were collected in Lake Anna and the WHTF by quarterly gill netting in 2000 (Table 3.2-2). A total of 710 fish weighing 288.0 kg was collected from four stations in the lake and two stations in the WHTF (Table 3.2-3). The 2000 total (710) was higher than 1999 (670) but lower than 1998 (817), while gill net biomass in 2000 (288.0 kg) was lower than biomass totals in both 1999 (296.47 kg) and 1998 (360.8 kg). Of the 710 fish collected, 535 (210.1 kg) were collected in the lake and 175 (77.9 kg) were collected in the WHTF. The February survey yielded the greatest number and total weight of fish collected representing 31% of the total number of all fish collected and 38% of the total weight of all fish collected, from all stations combined.

Table 3.2-3 also includes the average number and weight of fish collected per net set for each station for comparison of catch per unit effort by number (CPUE-N) and weight (CPUE-W). CPUE-N for all stations combined in 2000 was 29.6 fish per net while CPUE-W was 12.0 kg per net. These values are compared to CPUE in previous years in Figure 3.2-2. Over the last 10 years, CPUE-N has ranged from 42 to 28 with a mean of 30, while CPUE-W has ranged from 16 kg to 12 kg with a mean of 14 kg. Figure 3.2-2 also indicates that the size of fish collected by gill net has increased in recent years (1995-2000) because CPUE-N has decreased during this period while CPUE-W has remained high.

When the catch per unit effort is compared among stations in 2000, CPUE-N ranged from a low of 17.3 fish per net at the Lagoon 3 Station to a high of 74.0 fish per net at the North Anna Arm Station (Table 3.2-3). Likewise, CPUE-W ranged from a low of 6.3 kg per net at the Lagoon 3 Station to a high of 20.6 kg at the North Anna Arm Station. This is consistent with past data.

Table 3.2-4 presents the relative percentages of species collected in terms of numbers and weights by gill netting in 2000. The numerically dominant species collected in the lake was gizzard shad Dorosoma cepedianum, followed by striped bass Morone saxatilis, black crappie Pomoxis nigromaculatus and white perch Morone americana. These results are similar to data collected in 1999 and 1998 and are also consistent with other years. The dominant species in the lake relative to biomass was striped bass followed by gizzard shad and channel catfish Ictalurus punctatus.

The numerically dominant species collected in the WHTF in 2000 was also gizzard shad, followed by channel catfish, white catfish Ameriurus catus and white perch. The weight-dominant species in the WHTF in 2000 was common carp Cyprinus carpio followed by gizzard shad, channel catfish and white catfish.

Due to their relatively high numbers, gizzard shad have generally ranked high in biomass catch in both the lake and WHTF. The larger but less abundant channel catfish, common carp and white catfish have consistently ranked high in biomass in both places with annual ranking depending on the variation in catch. Striped bass, have consistently comprised a large portion of the biomass in the lake but not in the WHTF.

3.3 Fish Population Studies - Electrofishing

Methods

Boat electrofishing was used in 2000 to evaluate the assemblage and abundance of fish populations which normally occupy the shoreline habitat. The techniques, stations, and frequency have remained virtually unchanged since 1972. Sampling was performed in February, June, August, and November at the stations identified in Figure 3.2-1. Each station is 100 meters in length and normally includes a brush pile except for the dike stations which are comprised of uniform rip-rap.

All fish collected were either returned to the laboratory for processing or released in the field, e.g., larger game fish were measured, weighed, and released. In the laboratory, at least twenty-five (25) individuals per species from each station were measured to the nearest millimeter total length and weighed to the nearest 0.1 gram. Those individuals over twenty-five (25) per species were enumerated and bulk weighed. Surface water temperature (°C), dissolved oxygen (mg/l), pH and conductivity (Φmhos) were recorded at the time of each sample collection (Table 3.2-1).

Results

Twenty-one (21) species of fish representing eight (8) families were collected by electrofishing operations in the lake and WHTF in 2000 (Table 3.3-1). A total of 5,226 fish weighing 105.4 kg was collected from the five stations in the lake and the four stations in the WHTF during the 2000 sampling period. The total number of fish collected in 2000 (5,226) approximated the total number collected in 1999 (5,277) and was lower than the total in 1998 (6,991). Electrofishing biomass in 2000 (105.4 kg) was lower than that of 1999 (106.9 kg) as well as 1998 (83.1 kg). In 1998, Lake Anna fell to 2.6 feet below normal pool for an extended period dewatering much of the shallow shoreline fish habitat. It is thought that small fishes may have migrated to the rip-rap dike habitat as shoreline habitat declined during this period thereby inflating electrofishing totals.

Of the 5,226 fish collected in 2000, 2,476 (72.6 kg) were collected from the lake and 2,750 (32.8 kg) were collected from the WHTF (Table 3.3-2). When the data are compared seasonally, the 2000 electrofishing results are similar to previous years with the greatest numbers of fish being collected in the winter (February – 1,610 individuals) and fall (October

– 2,381 individuals) surveys. Typically, in the fall, recruitment of the young-of-year (YOY), plus the return of fish to shallow water as the weather moderates generally increases the number of fish available to collection by shoreline electrofishing.

Table 3.2-2 also includes the average number and weight of fish collected per electrofishing sample for each station for comparison of catch per unit effort by number (CPUE-N) and weight (CPUE-W). CPUE-N for all stations combined in 2000 was 145 fish per sample while CPUE-W was 30 kg per sample. These values are compared to CPUE in previous years Figure 3.3-2. Over the last 10 years, CPUE-N has ranged from 112 to 194 with a mean of 127, while CPUE-W has ranged from 28 kg to 41 kg with a mean of 33.9 kg. CPUE-N in 2000 was consistent with most previous surveys with the exception of 1998 when large numbers of small fishes were concentrated on the dike stations as discussed previously. CPUE-W was above average in 2000 and within the range of previous biomass estimates. It is interesting to note that biomass decreased in 1998 when fish numbers increased reflecting the relatively high numbers of small fish concentrated at dike stations that year.

When the catch per unit effort for each electrofishing station in 2000 are compared, CPUE-N ranged from a low of 56 fish per sample at the North Anna Arm Station to a high of 379 fish per sample at the Dike 1 -- WHTF Station (Table 3.3-3). CPUE-W ranged from a low of 0.7 kg per sample at the Lagoon 3 Station consisting of mostly small bluegill to a high of 7.6 kg at the North Anna Arm Station (primarily due to the capture of the larger common carp at this station).

The numerically dominant species collected in both the lake and WHTF by boat electrofishing in 2000 was the bluegill sunfish (Table 3.3). Bluegill sunfish ranked first in weight in the WHTF, followed by largemouth bass. In the lake, largemouth bass ranked first in weight followed by common carp and bluegill sunfish. These results are similar to those of 1999 and 1998 as well as those in the historical records.

When lake gill netting and electrofishing data for selected species are combined and examined for size class distribution, the data indicate certain population trends. Similar to 1998 and 1999, young-of-year (YOY) was the predominant size class of largemouth bass in 2000 although all the three size classes were well represented each year (Figure 3.3-3). Fewer YOY and intermediate size bass were collected in 2000 than in 1998 and 1999, while more harvestable bass were caught. Figure 3.3-4 demonstrates a decrease in the relative abundance of the YOY class and an increase in the relative abundance of intermediate and harvestable size classes from 1998 to 2000.

Lake Anna ranked third among bodies in the State of Virginia for largemouth bass citations with 72 being reported in 2000. A citation for largemouth bass is awarded for fish greater than 55.9 cm in length of 3.6 kg in weight. The lake was also third in black crappie citations as well with 26 being reported in 2000 (greater than 38.1 cm in length of 0.91 kg in weight).

Overall, the data for gillnetting and electrofishing in 1998-2000 reveal no major changes in the lake ecosystem when compared to past data. Lake Anna continues to support a healthy, well-balanced biological community.

3.4 Aquatic Vegetation

Methods

Hydrilla is an exotic, submerged, aquatic macrophyte which, in most bodies of water, has the ability to grow and spread rapidly. The primary method of reproduction is by fragmentation. Hydrilla also produces overwintering structures in two (2) separate areas of the plant: tubers, produced by the roots in the hydrosoil; and turions, formed at the leaf axils of the plant. Each has the ability to produce new plants at the beginning of each new growing season.

An annual aerial survey is conducted to map hydrilla growth in Lake Anna. The 2000 survey of Lake Anna was conducted in late November. The survey is conducted by helicopter with personnel from VDGIF and the Company. The entire shoreline of the lake and WHTF is surveyed to document areas of hydrilla colonization. The locations of observed hydrilla are marked on a topographic map of Lake Anna and returned to the laboratory for computerization. The computerization of the data allows the acreage of hydrilla to be calculated, and also production of maps indicating the location of the hydrilla.

Results

Acres of hydrilla colonization of Lake Anna and the WHTF in 2000 are mapped in Figures 3.4-1 through 3.4-5. Hydrilla acreage decreased in Lake Anna proper from 113 acres in 1999 to 94 acres in 2000. A decrease was noted in the WHTF from 35.5 acres in 1999 to 29 in 2000. The totals for 2000 are the lowest since 1995, the year after sterile grass carp were stocked by Dominion in the WHTF.

The amount of habitat available for hydrilla colonization in the lake and WHTF is estimated in Table 3.4-1 as the acreage of reservoir bottom with 15 feet or less water depth. The acreage of actual hydrilla coverage in 2000 is also presented so that a percentage of available habitat that is currently present (29 acres) can be calculated. In 2000 only 2% of habitat available to hydrilla was actually colonized in both the lake and WHTF. This continues a general decline in total acreage for the lake and WHTF since 1995. The sudden drop in acreage in 1995 is probably the result of grass carp stocking and also adverse weather conditions which greatly increased the turbidity in the lake during the growing season that year.

Not only has the total acreage of hydrilla colonization decreased but also the nature of the plant itself. The hydrilla plants in 2000 generally consisted of short, stunted plants with minimal vertical growth and biomass production. This has been the growth pattern since grass carp were stocked and is attributable to carp grazing on the plants.

To assess the effectiveness of hydrilla control by the grass carp, exclusion areas were established in 1995 in the WHTF and 1997 in the lake. Exclusion areas are 10 foot by 10 foot square fenced areas which prevent grass carp from feeding on the hydrilla inside. The low lake level in 1998 resulted in dewatering the exclusion area in the WHTF thereby rendering it ineffective for hydrilla growth evaluation. This dewatering also affected the exclusion areas in 2000. Because of the low water hydrilla was present in only three of the six exclusion areas, two in the main lake and one in the WHTF. Historically, the exclusion areas have exhibited hydrilla growth inside the fenced area while the area around them has been devoid of hydrilla plants. This pattern of growth within the protected areas in the three areas in 2000 continued and is consistent with the literature in other lakes where grass carp have been stocked (Webb, et al, 1994).

One observation that can be made regarding the continued decrease of acreage of hydrilla in 2000 is that atypical weather conditions which interfered with hydrilla growth in 1998, and perhaps continued into 1999, combined with the sterile grass carp seem to be producing the desired and predicted results, i.e., control of the growth and biomass without eliminating hydrilla totally from the ecosystem of the lake.

3.5 Conclusions

- North Anna Power Station in 2000 operated at the highest generation levels since 1978 when commercial operations began. The three year period of 1998-2000 also produced the highest average generation level since 1978.

- The 2000 water temperature data from the continuous recorders indicated water temperatures within the ranges of data from previous years.

- Thermal stratification patterns measured in 2000 indicated similar stratification patterns to those in 1998 and 1999 and followed closely previously reported data.

- Gill netting and electrofishing data showed little change in the abundance of fishes and the taxonomic composition of the fish population during 1998 through 2000.

- Based on numbers of citation largemouth bass and black crappie reported by anglers, Lake Anna ranked as the third best trophy lake for both largemouth bass and black crappie in the state for the period 1998-2000.

- Overall hydrilla acreage for 2000 decreased in the lake and WHTF with the hydrilla plants being 10 to 20 cm in length and thereby producing limited biomass. The overall acreage of hydrilla decreased during the period 1998-2000.

3.6 Recommendations

- Continue the biological monitoring of Lake Anna and the WHTF at its present level.

- Reduce the lake temperature surveys to twice a year. The data collected continues to show consistent thermal patterns which have been historically reported. Reducing the surveys to twice a year will have no adverse effect on the environmental monitoring of Lake Anna and will fully meet the permit requirements.

4.0 North Anna River

4.1 Temperature

Methods

Water temperatures (°C) were recorded hourly at station NAR-1 in the lower North Anna River during 2000 (Figure 4.1-1) using an Onset temperature recorder. This instrument has an accuracy range of ±0.5°C. Station NAR-1 is located approximately 1 km below the Lake Anna dam.

Results and Discussions

Water temperatures for 2000 were highest from June through September with mean monthly water temperatures 27°C (Table 4.1-1). A maximum temperature of 31.2° C was recorded at NAR-1 in July and again in August 2000. Historically, maximum water temperatures have occurred in July or August. A minimum temperature of 5.4° C was recorded at NAR-1 in January 2000.

4.2 River Flow

Methods

River discharge (cfs) data were obtained from the United States Geological Survey (USGS) to document the timing and magnitude of hydrologic events. These events, along with water temperature, are among the most important abiotic factors affecting the abundance and distribution of stream organisms. Data were obtained from USGS gaging station 01671020 (Hart's Corner) near Doswell, Virginia. The station is located approximately 37 km downstream of the Lake Anna dam at NAR-6 (Figure 4.1-1).

Results and Discussion

The pattern of seasonal flows in the North Anna River has generally been characterized by high flows in the winter and spring, reduced flows during summer, and lower flows during late summer and early autumn. This is a pattern commonly exhibited by many rivers draining the eastern United States, and is generally reflective of annual rainfall patterns.

In 2000, North Anna River flows for the period January - March were below the 1998-2000 average with mean monthly flows between 200 and 400 cfs (Figure 4.2-1). Typical of historical patterns, flows generally decrease from April through June. This pattern was exhibited in 2000 with the exception of increases due to sporadic rain events in mid and late April when flows ranged from 1200 – 2300 cfs. The maximum daily mean recorded in 2000 was 2350 cfs on April 18 and was associated with a short-term rain event. Mean daily flows rarely exceeded 100 cfs in July, August and September and 79% of the daily mean values calculated for this period were below 100 cfs.

The historical flow patterns for the period from 1980-2000 indicate that summer and fall river flows are moderately low. A comparison with the 2000 flows for this same period demonstrates exacerbated low mean flows indicative of ongoing drought conditions.

4.3 Fish Population Studies-Electrofishing

Methods

Abundance and species composition data for the North Anna River fish assemblage in 2000 were collected during electrofishing surveys. Consistent sampling techniques have been used in all North Anna River electrofishing surveys since 1981.

An approximately 70-m reach of riffle/run type habitat is sampled at each station with an electric seine (Virginia Power 1986). Prior to sampling, each reach is blocked at the downstream ends with a 6.5-mm mesh net. Sampling is conducted by working the electric seine from bank to bank in a zigzag pattern from the upstream to the downstream end of the section. Nearby pool type habitats are then sampled for 10 minutes of effort with a backpack electrofisher. Fish sampled by electric seine and backpack electrofisher were collected using 6.5-mm mesh dip nets.

Most fish collected are preserved in 10% formalin and transported to the laboratory for appropriate processing. Some larger fish are weighed and measured in the field and released. In the laboratory, a maximum of 15 individual specimens of each species is weighed to the nearest 0.1 g and measured to the nearest one (1) mm total length (TL). If more than 15 specimens of a species are collected, those in excess of 15 are counted and weighed in bulk. Electric seine and backpack electrofisher collections are then pooled by station and survey month for analyses.

Sample frequency for electrofishing is typically once per month each year in May, July and September. In 2000, electrofishing surveys on the North Anna River were conducted in May, July, and September. It was necessary to delay the July electrofishing survey until August due to a rain event.

Results and Discussion

A total of 688 fish was collected from the North Anna River during electrofishing surveys conducted in 2000 (Table 4.3-1). This compares to a total of 2,258 fish in 1999. Electric-seine collections were not made in September, 2000 due to high river flows; however, backpack electrofishing was conducted at each of the four sites. Attempts were made to reschedule the survey but either weather conditions or available manpower were problematic. Calculated estimates were made to determine the effect of the missed portions of September 2000 survey on the overall catch for the year.

The average number of fish collected by electric-seine during September for the 10 year period is 448 (Table 4.3-2).

This number was obtained by adding all of the totals for September electric-seine collections and dividing the total by ten which is the number of years sampled. This average number of 448 then represents an average of what was missed by not doing the September collections. Adding this "missing average" to the known total of 688 equals a new total of 1,136.

Complete sets of numbers are available for the years of 1990, 1991, 1992, 1993, 1997, 1998 and 1999 (Table 4.3-2). The adjusted number for 2000 of 1,136 compares to the other years for which complete data sets are available as being in the lower 1/3 of the data set. When comparing all years graphically (Figure 4.3-1) it becomes very apparent that the years in which there are missed samples represent the lowest years for total fish collected.

The 2000 collection includes 23 species and seven (7) families (Table 4.3-3). Over the past 18 years, 49 species of fish have been collected from the North Anna River with annual totals ranging from 18 to 32 species.

A common characteristic of stream systems is the tendency for a few species to numerically dominate the stream fish assemblage (Matthews 1982). Six (6) to 10 species have accounted for greater than 80 percent of the North Anna River electrofishing catch from all stations in any year since sampling began in a consistent manner in 1981 (Table 4.3-4). This trend continued in 2000 with 6 species accounting for greater than 80 percent of all fish collected. These species were, in decreasing order by numbers, redbreast sunfish Lepomis auritus, satinfin shiner Cyprinella analostana, redfin shiner Lythrurus ardens, american eel Anguilla rostrate, margined madtom Noturus insignis, fallfish Semotilis corporalis and shield darter Percina peltata. These species have consistently been among the most abundant species collected from the North Anna River since 1981.

Table 4.3-5 indicates that in 2000, irrespective of missing samples, station NAR-1 yielded the greatest numerical catch followed by, in decreasing order, NAR-4, NAR-6 and NAT-2. In terms of biomass (total weight) in 2000, NAR-1 ranked first followed by NAR-2, NAR-6 and NAR-4.

This numbers ranking in 2000 compares to 1998 and 1999 when NAR-2 yielded the most fish collected. Biomass for all three (3) years is greatest at NAR-1 probably attributable to numbers of the larger centrachids and eels collected at NAR-1 when compared to the other stations.

Past surveys have indicated that high winter and spring flows often result in decreased North Anna River catches. In 1993, the relationships between flow and annual fish abundance were examined. Based on the results of Spearman's correlation analysis (Hollander and Wolf 1973), low late winter/early spring flows tend to be conducive to relatively high electrofishing catches later in the year, and conversely, the high flows early in the year tend to result in low electrofishing catches (Virginia Power, 1994). This may have contributed somewhat to the lower numbers of fishes collected in 2000 when early spring flows were near the normal high flow conditions for the twenty year period 1980-2000.

4.4 Fish Population Studies- Direct Observation

Methods

To further amplify and understand fish population studies in the North Anna River, abundance and distribution data for smallmouth bass Micropterus dolomieu and largemouth bass were gathered via direct observation using snorkel surveys. Consistent observation techniques have been used in snorkel surveys since 1987 with some variation in sampling frequency at some stations among years due to instances of high river flow conditions, electrical storms, etc.

In 2000, snorkel surveys were conducted during July, August, and September. Four (4) stations were sampled twice per month in August and September; NAR-1, NAR-2, NAR-4, and NAR-5 (Figure 4.1-1). Primarily due to a relocation of our laboratory in July of 2000 as well as the planning, etc., associated with the move, only one survey was conducted in July as opposed to the normal two (2) surveys.

Abundance estimation procedures were identical to those employed since 1987 (Virginia Power 1988). Counts of smallmouth bass (SMB) and largemouth bass (LMB) were made while swimming 100 m transects along the north and south banks of each station. Transects followed an approximately one meter depth contour.

All bass sighted were categorized by species as to young-of-year (YOY) ($\leq$120 mm), stock-size (120<SMB<280 mm or 120<LMB<305 mm), or quality-size (SMB$\geq$280 mm or LMB$\geq$305 mm). In addition to size group, all bass sighted were categorized as to type of cover being used; bedrock ledge (Ledge), boulders (Boulder), instream woody debris (Wood), aquatic vegetation (Vegetation), or no apparent cover use (Open). Fish had to be within 0.5 m of a cover object at the moment of sighting to be included in a cover use category other than the Open category. Aquatic vegetation was included as a cover type beginning in 1993 due to annual increases in the amount of vegetation observed from 1990 through 1992, and apparent associated increase use by fish.

During each survey, three successive counts at each station were made at each bankside transect. Each observer made an independent estimate of the distance that YOY smallmouth bass (TL$\leq$120 mm) could be distinguished from YOY largemouth bass (TL$\leq$120 mm) at each station. Lateral visibility at each station was estimated by averaging the independent estimates of both observers. Counts of smallmouth bass and largemouth bass were converted to density estimates (number/hectare of bankside channel) to account for differences in average visibility among survey days and sampling stations. Density estimates for all smallmouth bass and largemouth bass larger than YOY size were pooled by species, station, and sample year to facilitate identification of species-specific and station-specific changes over time. Calculations of median density estimates by sample year and associated 95% confidence intervals were based on Walsh averages (Hollander and Wolfe 1973). YOY densities were not calculated as it was doubtful that YOY were as susceptible to the observation technique as were larger fish, due primarily to their small size and cryptic nature.

Cover utilization data from the first of three sets of observations obtained during each snorkel survey were used to examine differences in cover use by smallmouth bass and largemouth bass. Data from only the first count were used because it was assumed fish observed during the first count would be relatively undisturbed by divers, whereas fish observed on the second and third counts may have changed their positions in response to divers passing by during the first count.

Results and Discussion

Snorkel surveys for 2000 were conducted between 0830 and 1429 hours at river temperatures ranging from 14.7 to 28.8°C and average visibility ranging from 1.0 to 4.0 m. Unlike previous years, when largemouth bass were the numerically dominant species observed at the upstream stations (NAR-1 and NAR-2), only at NAR-1 were largemouth the dominant species in 2000. Largemouth bass numbers observed at NAR-2 were similar to fish numbers observed at NAR-4 and NAR-5, the lower river stations where few largemouth bass are generally seen (Table 4.4-1). Historically, largemouth bass have primarily dominated fish counts at the upper stations (NAR-1 and NAR-2) and smallmouth bass numbers have been greater at the lower stations (NAR-4 and NAR-5). However, in recent years, both species have occupied the entire study area. Variability between the north and south bank at any station appeared to be related to habitat complexity, i.e., fewer fish were observed along banks characterized by monotypic habitat than along banks with a variety of habitat types.

Density estimates for largemouth bass and smallmouth bass observed in 2000 for stations NAR-1, NAR-2, NAR-4 and NAR-5 are compared to historical density estimates in Figures 4.4-1 through 4.4-4. These estimates do not include young of year (YOY) size fish (TL# 120 mm) as it is doubtful that the smaller individuals are as susceptible to the observation techniques as are larger fish. In general, largemouth bass have been more abundant at the two uppermost stations (NAR-1 and NAR-2) than at the lowermost stations (NAR-4 and NAR-5), with the opposite evident for smallmouth bass. Largemouth bass densities at NAR-1 and NAR-2 averaged approximately 37 and 28 fish/hectare respectively over the study period, while densities at both NAR-4 and NAR-5 averaged approximately

7 fish/hectare. Conversely smallmouth bass densities averaged approximately 6 fish/hectare at NAR-1 and NAR-2 with average densities of 17 and 33 fish/hectare at NAR-4 and NAR-5 respectively. These trends have been evident during most but not all surveys. Densities calculated for 2000 decreased at all four stations (Figures 4.4-1 through 4.4-4). The most significant decrease was at NAR-4 (Figure 4.4-3) where largemouth and smallmouth bass median density values, previously 20 and 21.5 fish/hectare respectively in 1999 were zero for both species. Although largemouth and smallmouth bass are consistently observed at NAR-4 from year to year, their abundance appears more variable than at other stations. This has resulted in median density estimates of zero for largemouth bass occurring 7 of the 14 years of record (Figure 4.4-3). Smallmouth bass are generally more abundant, and density estimates higher, at NAR-4 with the exception of 1996 and 2000.

Hydrilla growth continues to pose problems for observers during the surveys. Low summer river flows and warm water temperatures provide an excellent environment for growth of the nuisance aquatic plant. Consequently, each year, the use of the wood structure is being reduced due to the shoreline patches of hydrilla. Each station has either a north or south shoreline with its entire length being impacted by hydrilla that typically extends 6-10 feet out from the bank. Observations made during these runs are generally limited to the outer edge of the hydrilla and open water. Therefore, hydrilla is a factor that is reducing the ability of the observer to make accurate counts and is thereby contributing to the low median densities found in 2000.

Observations of cover use by smallmouth bass and largemouth bass are difficult to interpret without accounting for the availability of various cover types. For this reason, cover use data obtained in 2000 are primarily presented for documentation purposes (Table 4.4-2).

When cover use data are pooled for all stations in 2000 (Table 4.3-3) smallmouth bass were usually associated with wood, boulder, and open water while largemouth bass cover usage follows a trend witnessed in recent years. With recent increases in the abundance of aquatic vegetation in the lower North Anna River largemouth bass appear to be shifting from making nearly exclusive use of woody debris to dividing their use between woody debris and aquatic vegetation (Virginia Power 1996, 1997, 1998, 1999). Smallmouth bass have generally been evenly distributed between all cover types and this was again the case in 2000.

4.5 Conclusions

- River flows were lower than normal throughout the year with the exception of several short-term rain or storm events. Mean daily flows in the summer of 2000 rarely exceeded 100 cfs with 79% of the daily means below 100 cfs.

- Numbers of fish collected in 2000 by electrofishing decreased at all four stations and total numbers were more similar to 1989, 1993 and 1996. High spring flows and missed surveys contributed to low fish numbers.

- Species composition of the 2000 North Anna River electrofishing catch was similar to previous years with six (6) species comprising 80% of the electrofishing catch in terms of numbers, and six (6) species comprising 83% of the electrofishing catch in terms of biomass.

- Underwater observations of smallmouth bass and largemouth bass made in 2000 in the North Anna River from the dam to U.S. Route 1 indicated smallmouth bass were numerically dominant in the lower reaches of the river and largemouth bass were more abundant in the upper reaches. However, in recent years, smallmouth appear to be moving upstream and likewise, largemouth moving downstream.

- Density estimates for both largemouth bass and smallmouth bass at all stations in 2000 were lower than average densities calculated for the entire study period. Dense hydrilla growth adjacent to shorelines is limiting the ability of observers to see and count fish and is thereby affecting numbers of observed fish.

- Observations of cover use made in 2000 illustrate that smallmouth bass are often associated with boulder, wood, and vegetation and largemouth bass with wood or vegetation.

1998-2000 Studies

Data presented in this report and previous reports indicate that the North Anna River below Lake Anna continues to support a diverse and stable fish assemblage. The taxonomic composition of the fish assemblage has been relatively stable from year to year, indicating power station effects are not evident in the North Anna River. The timing and magnitude of flood events appear to be the largest determinant factor governing fish abundance from year to year.

Further, the 1998-2000 data for the North Anna River continues to indicate that the river supports a mixed smallmouth and largemouth bass gamefish population. The historical trend of smallmouth bass being most abundant in the lower reaches and largemouth bass most abundant in the upper reaches may be in the process of changing. During the three year period of 1998-2000, more smallmouth bass have been seen in the upper reaches and more largemouth bass in the lower.

Comparative observations of cover usage of smallmouth bass and largemouth bass indicates that both species may segregate when choice of structure or cover is available. The overall preference for all size classes of both largemouth bass and smallmouth bass is wood and vegetation. Available wood habitat or cover is increasingly being lost due to growth and coverage of hydrilla.

Recommendations

- Over the last 10 years of monitoring, the fish assemblage of the North Anna River below Lake Anna has remained relatively stable and has been able to recover from natural occurrences such as flood events. However, because of the recent reduced flows as a result of ongoing drought conditions no changes in effort are proposed.

- Direct underwater observations for smallmouth bass and largemouth bass were initiated in 1987 to monitor species abundance, size, habitat preference and the expansion of their ranges. These observations should also continue at the current level of effort.

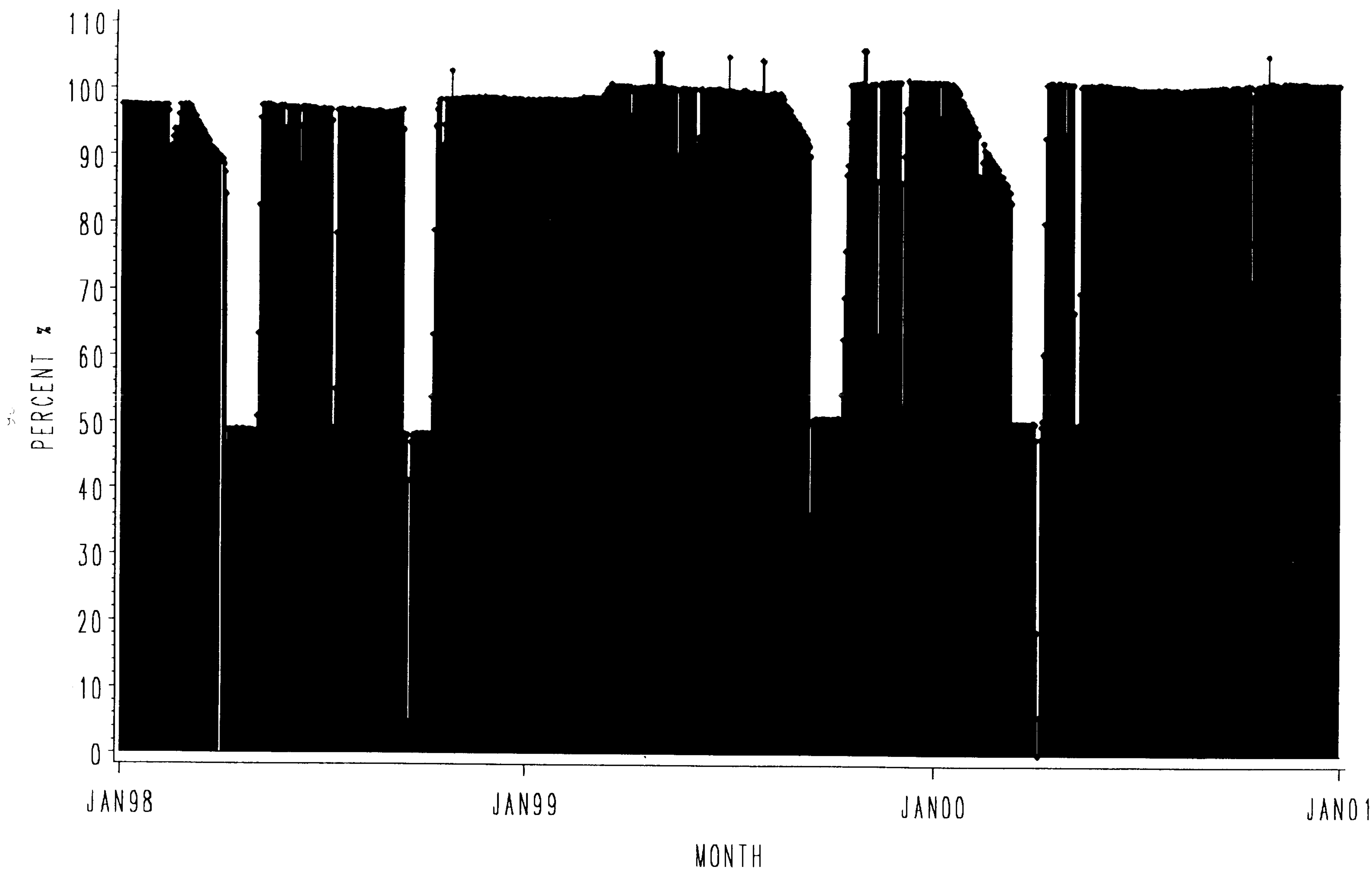

FIGURE 2.0-1. 1998-2000 NORTH ANNA UNITS 1 & 2 DAILY POWER LEVEL

FIGURE 3.1-1 Approximate location of fixed Endeco and Onset temperature recorders in Lake Anna and WHTF

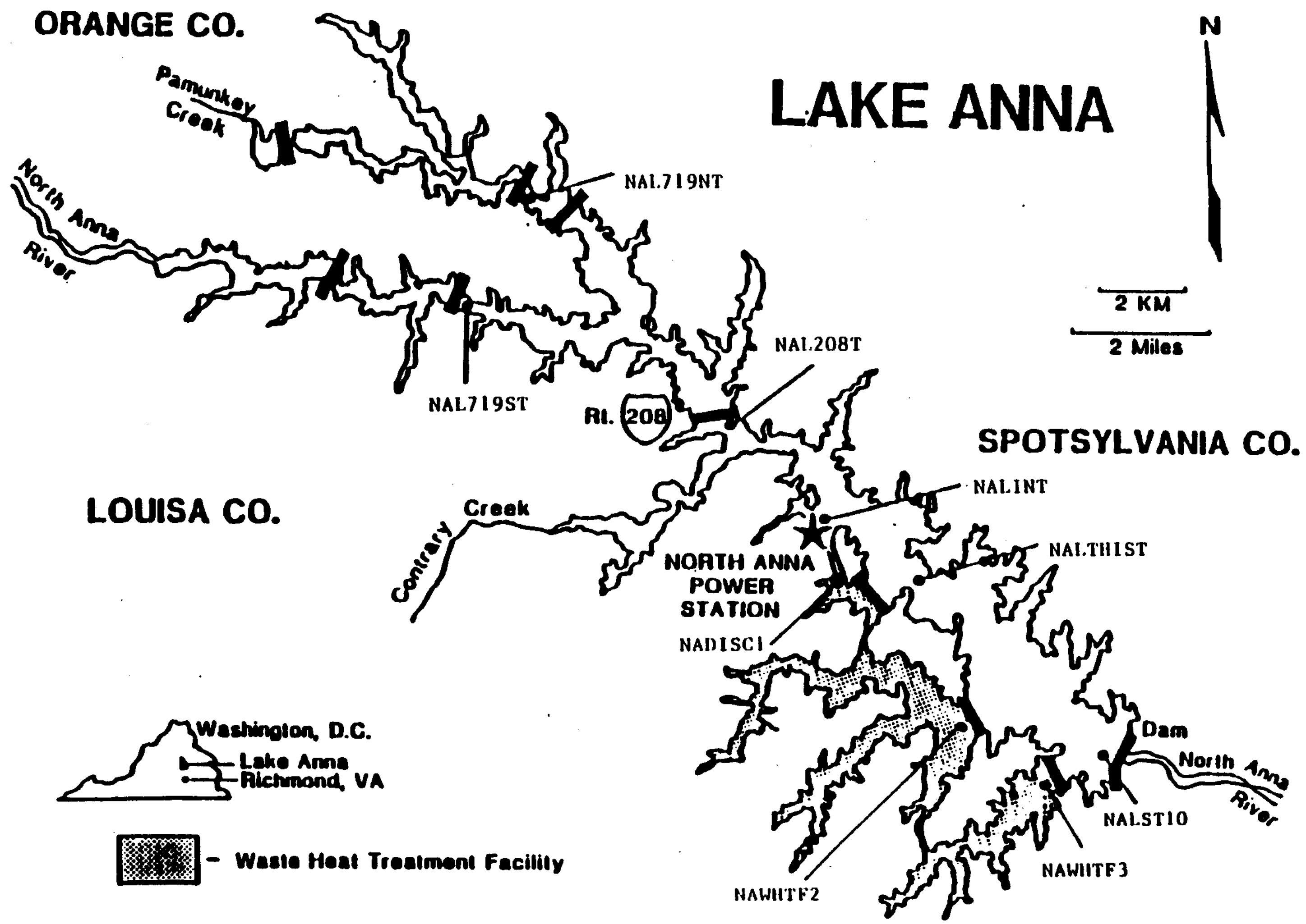

FIGURE 3.1-2 Approximate location of thermal plume sampling stations on Lake Anna.

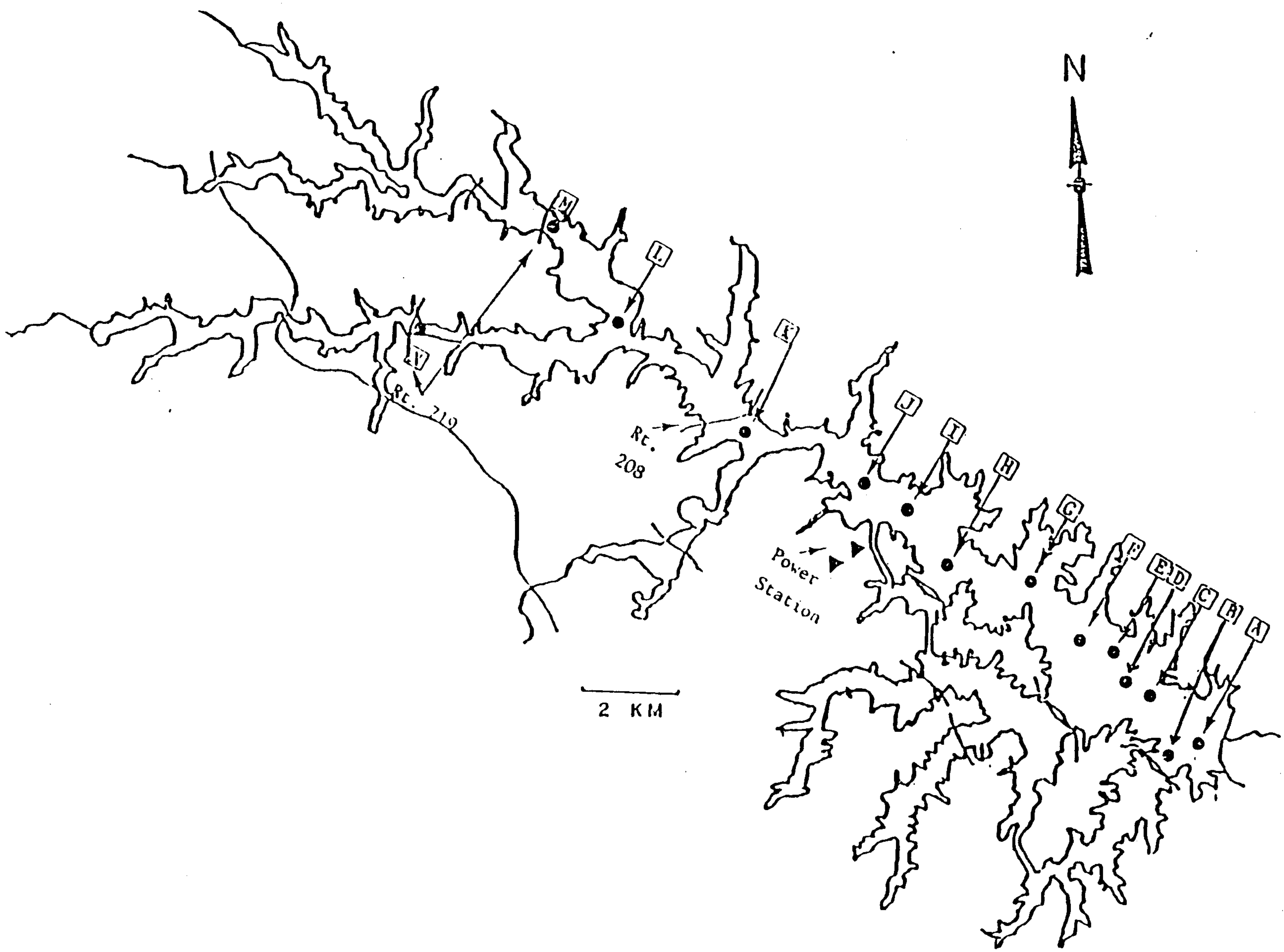

FIGURE 3.1-3 Upper Lake seasonal temperature patterns, Lake Anna station NAL719ST(1998-2000)

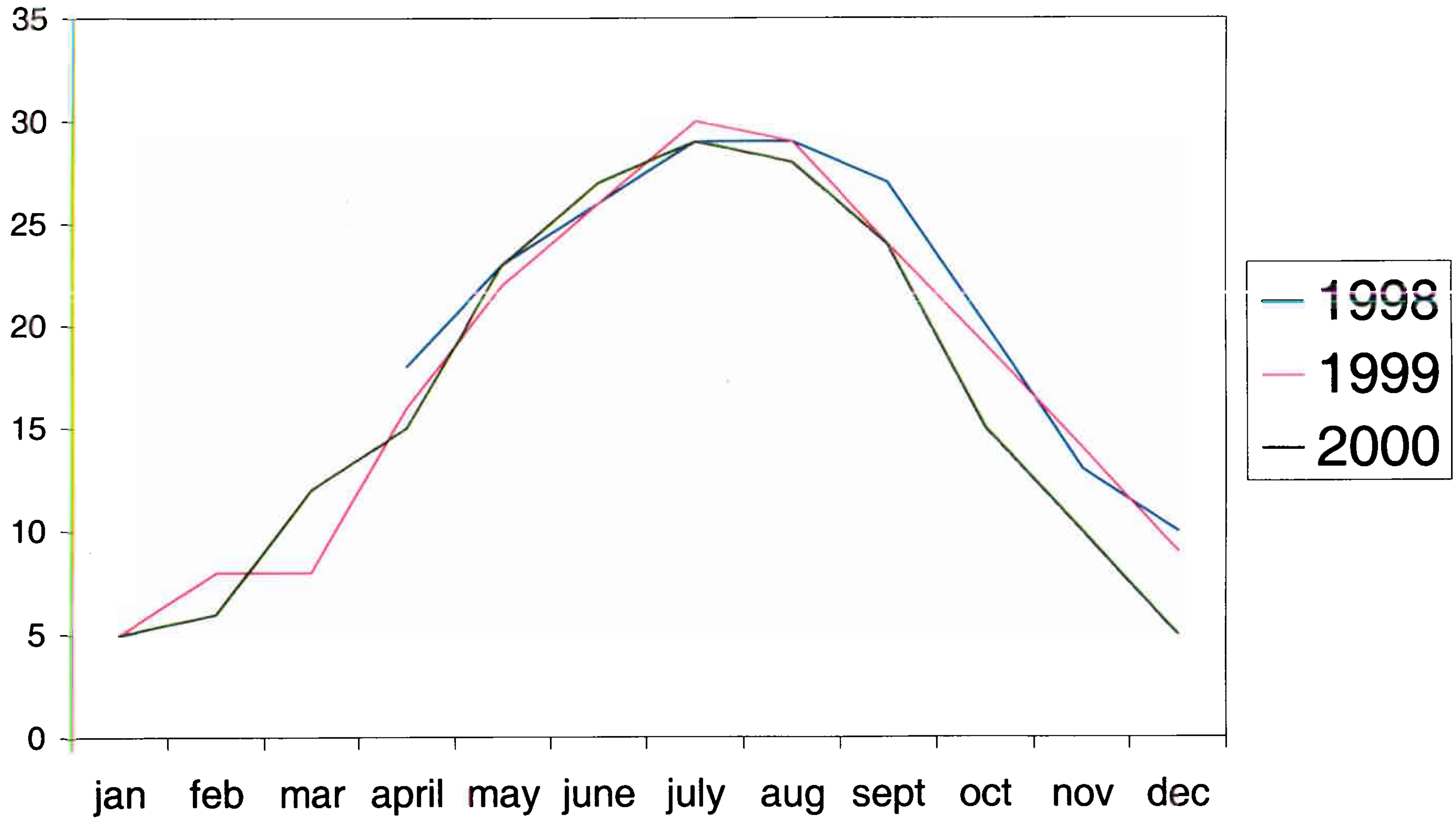

FIGURE 3.1-4 Mid-Lake seasonal temperature patterns, Lake Anna station NAL208T(1998-2000)

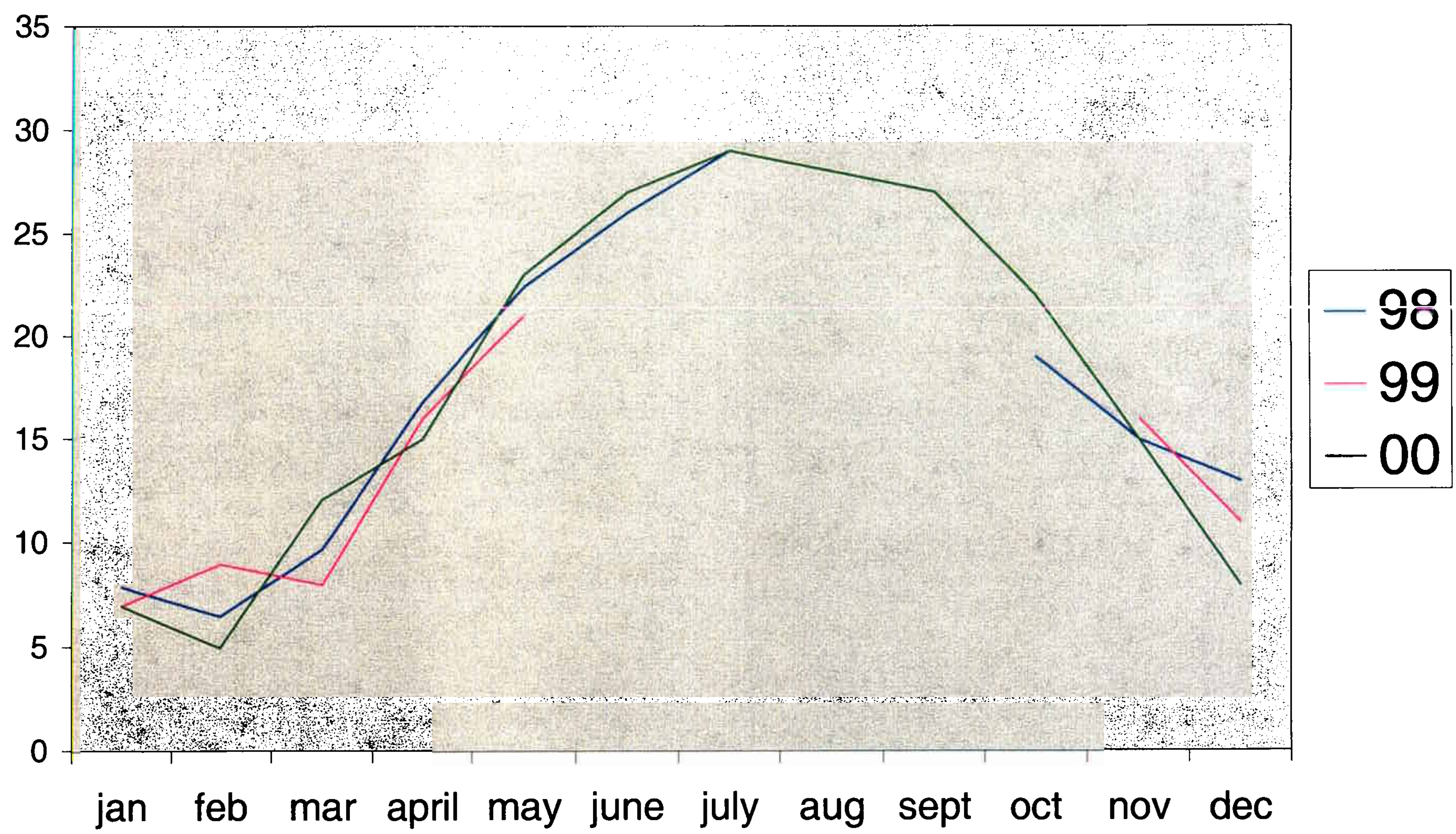

FIGURE 3.1-5 Lower Lake seasonal temperature patterns, Lake Anna station NALST10(1998-2000)

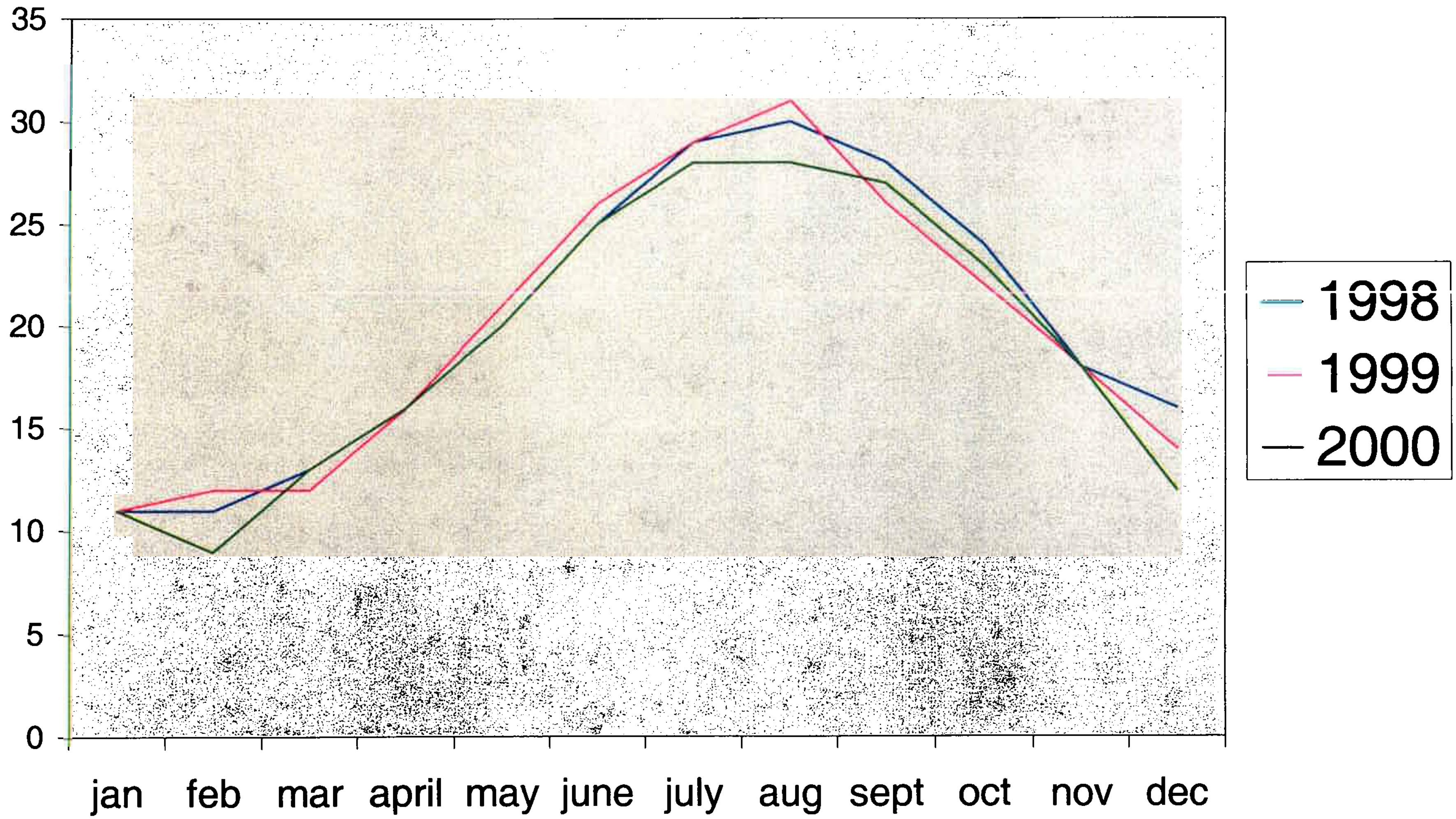

FIGURE 3.2-1 Location of Gill Netting stations on Lake Anna and WHTF

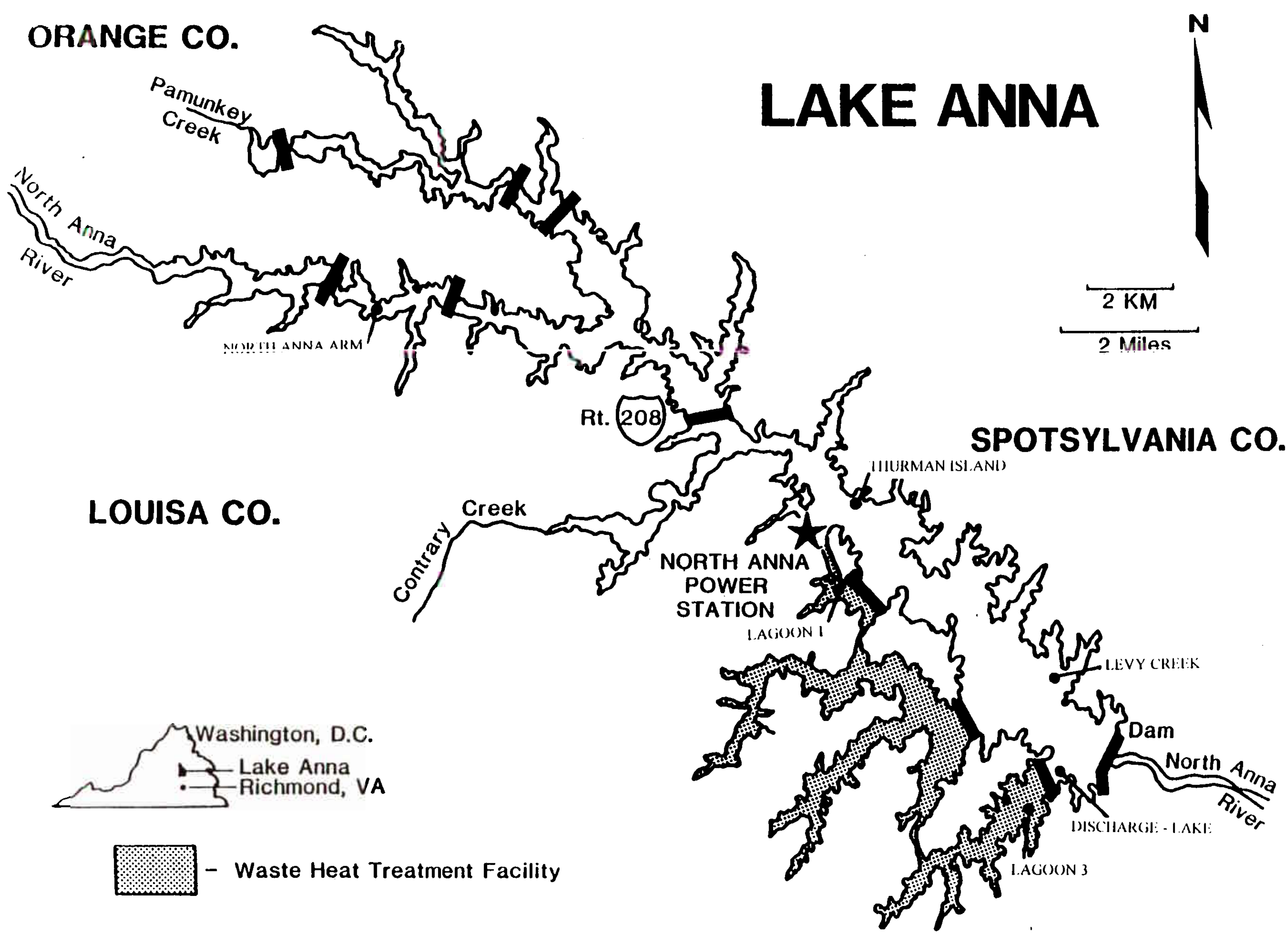

FIGURE 3.2-2 Gill Net data (1990-2000) average number and average weight (Kg)

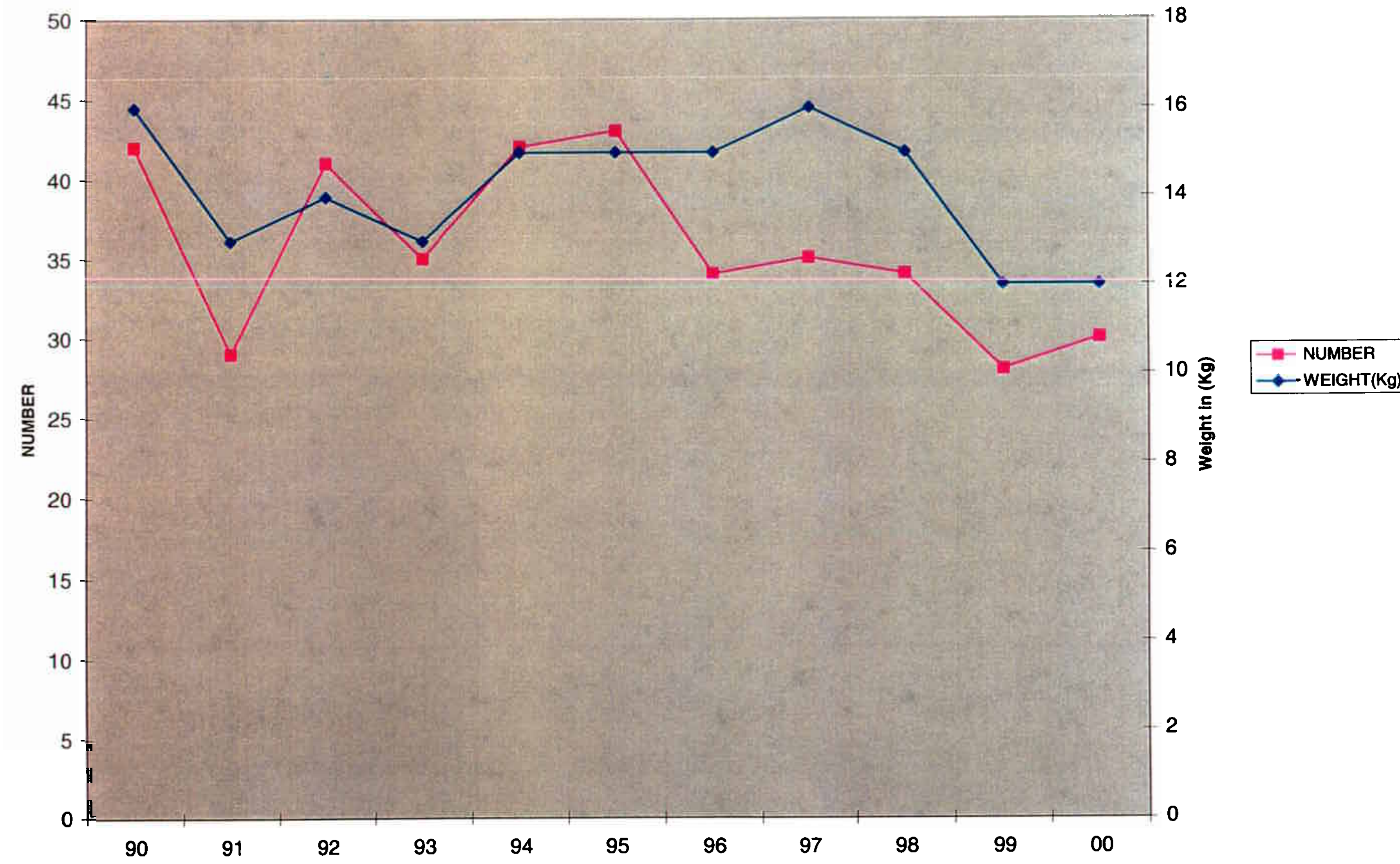

FIGURE 3.2-3 Catch per unit effort Electrofish and Gill Netting in Lake Anna 1990-2000

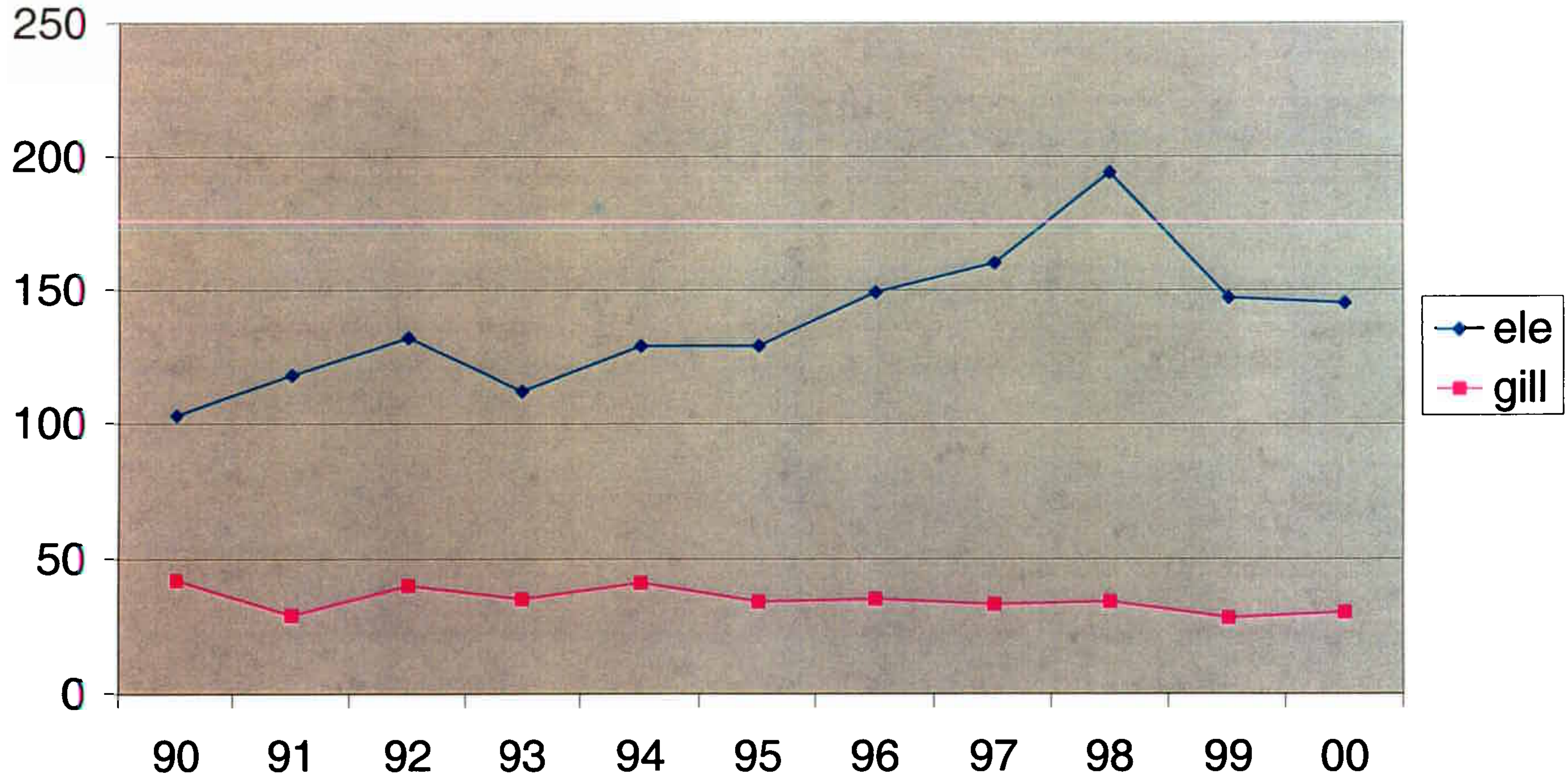

FIGURE 3.3-1 Approximate locations of Electrofish stations on Lake Anna and WHTF

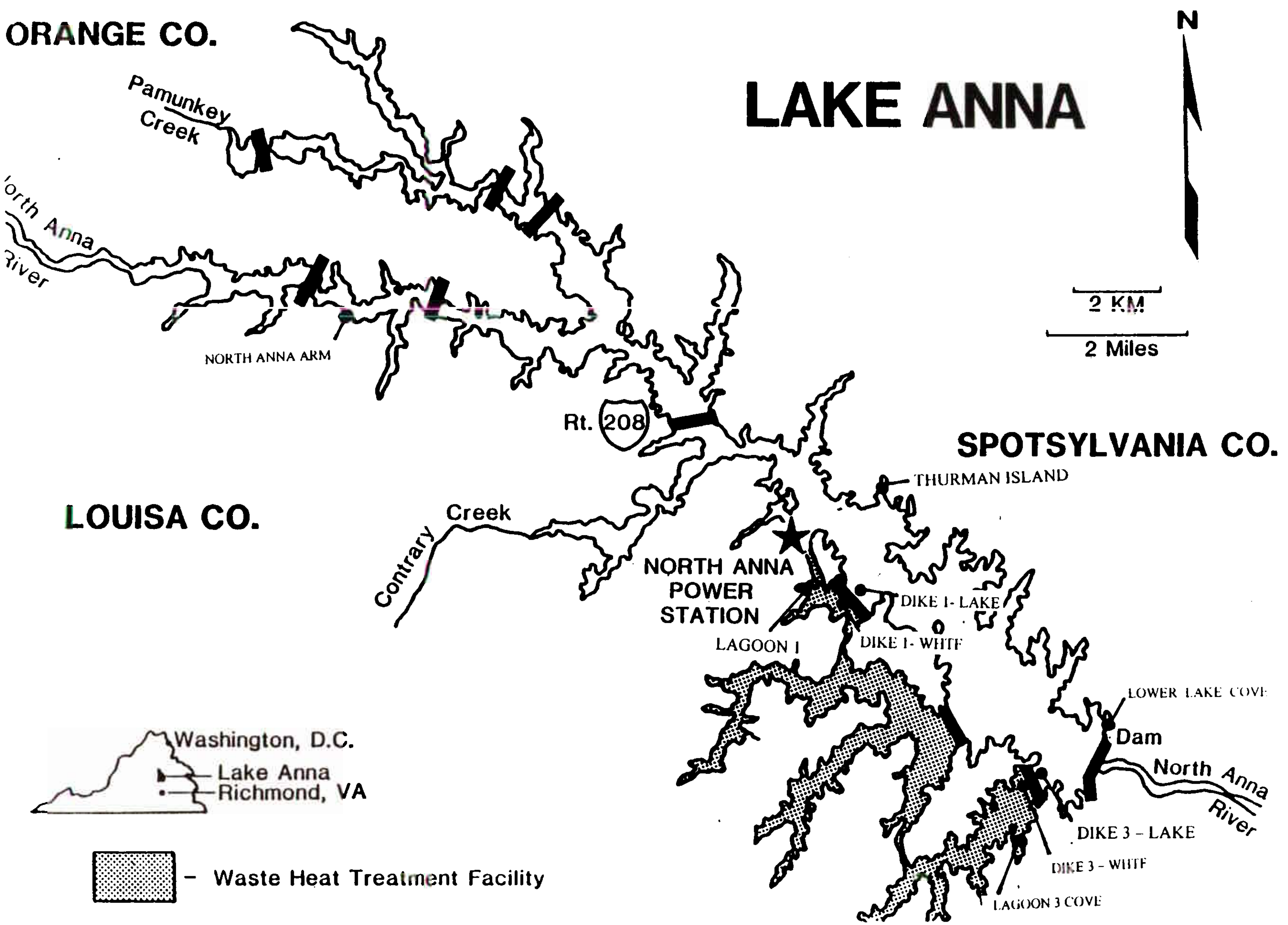

FIGURE 3.3-2 Lake Anna Electrofish data (1990-2000) average number and average weight (Kg)

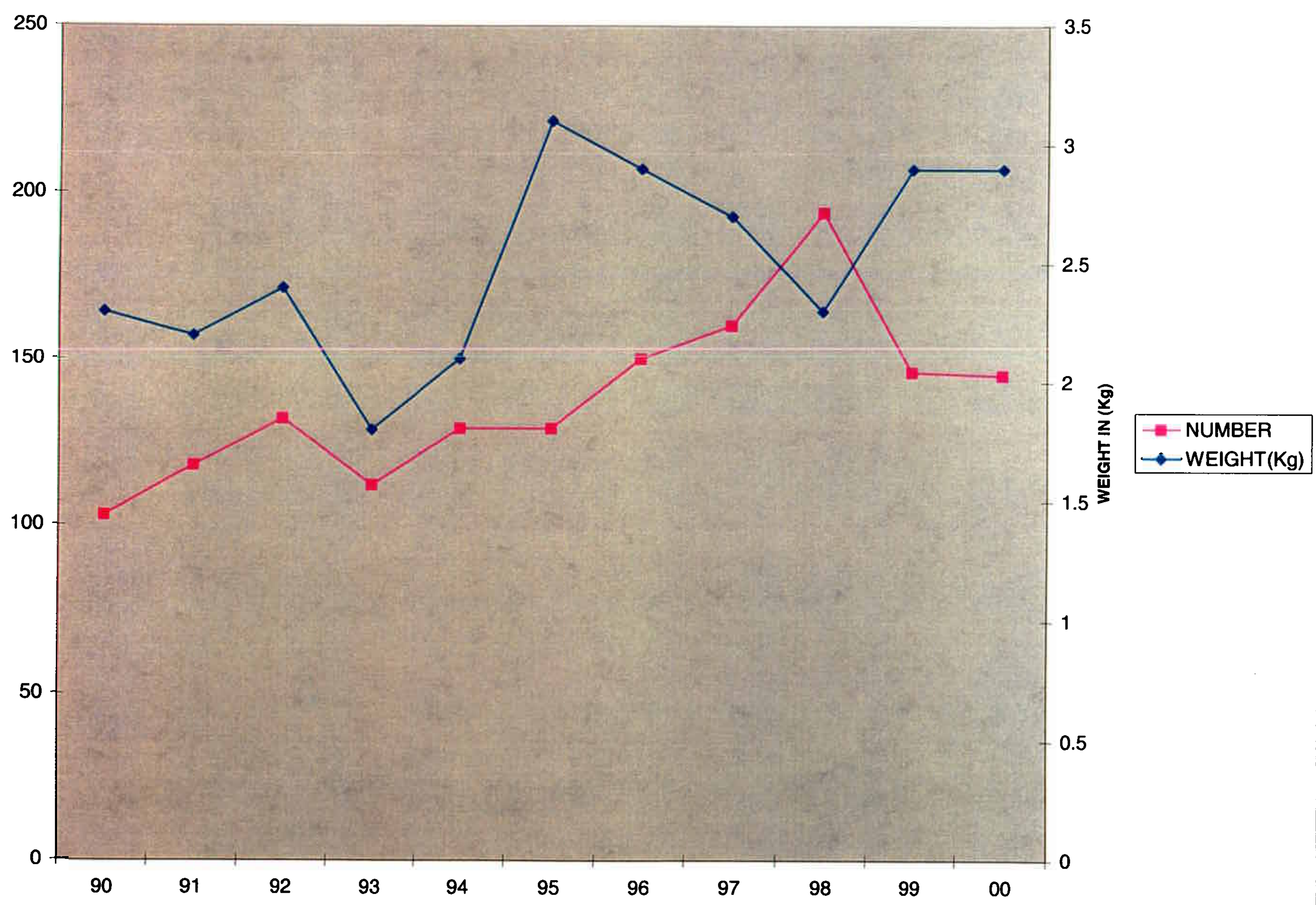

FIGURE 3.3-3 Composition of LMB catch in Lake Anna and WHTF (1998-2000)

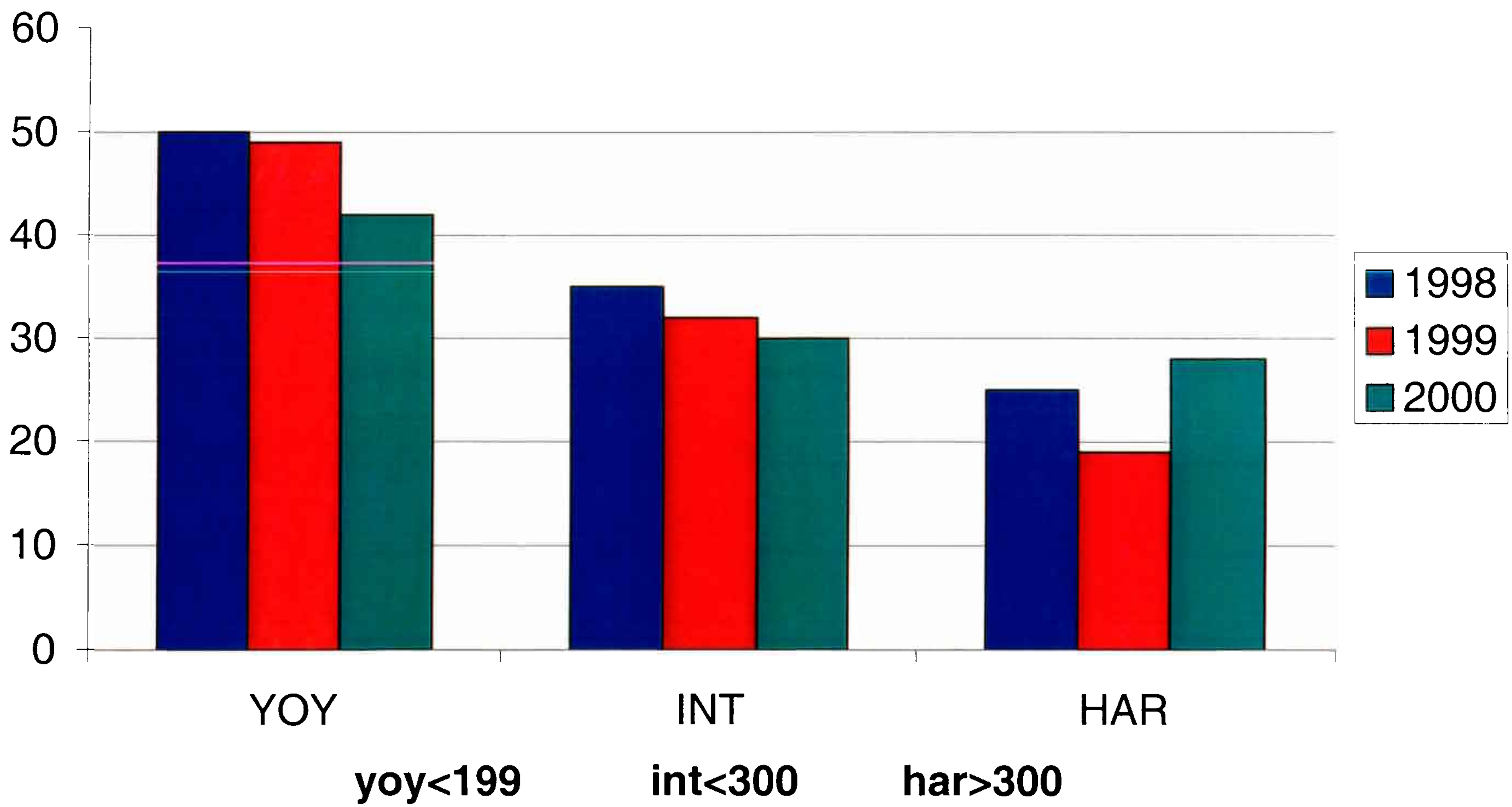

FIGURE 3.3-4 Composition of Bluegill catch in Lake Anna and WHTF (1998 - 2000)

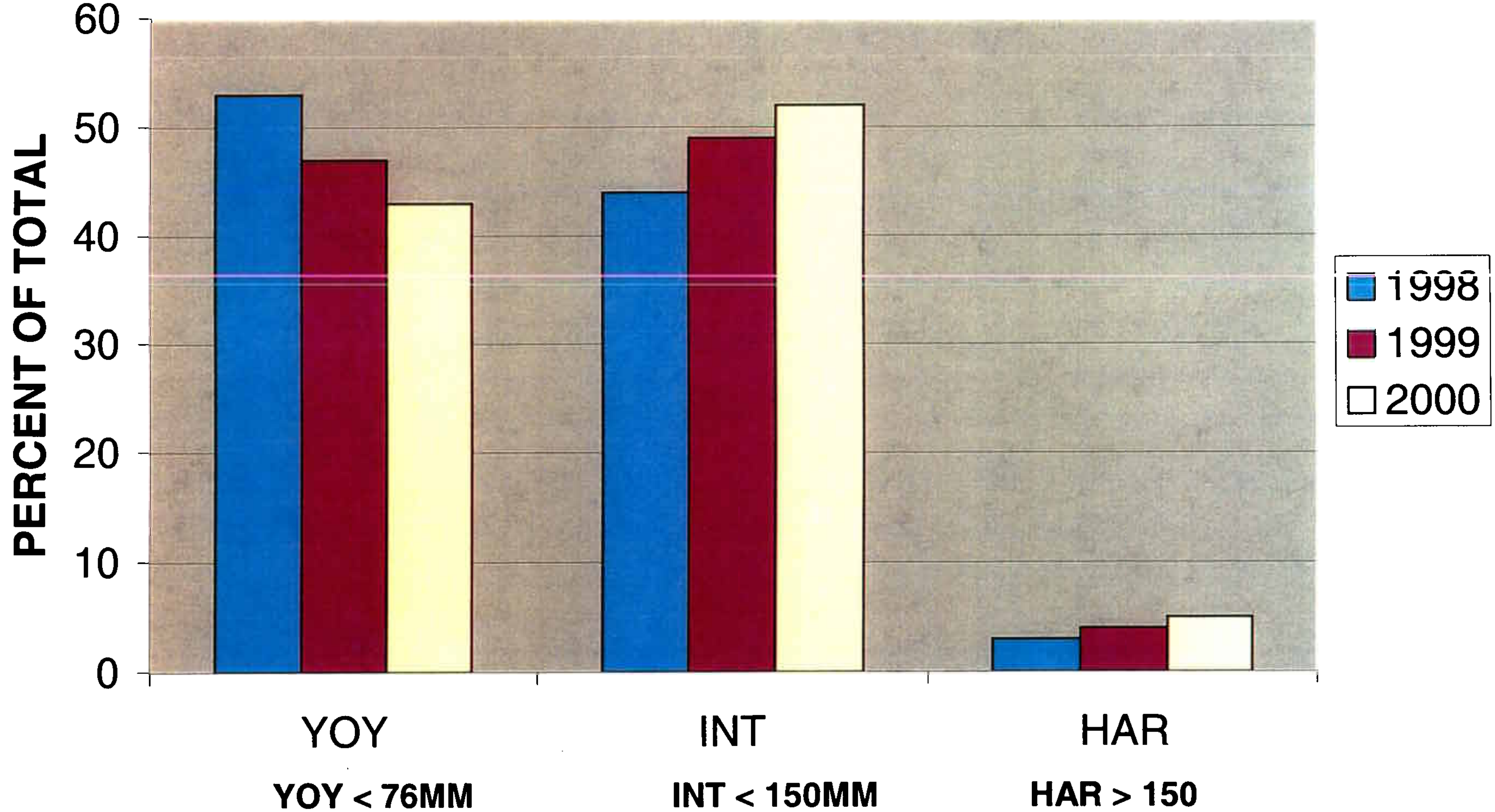

FIGURE 3.4 - 1 Lake Anna above Route 208 Bridge indicating hydrilla in 2000

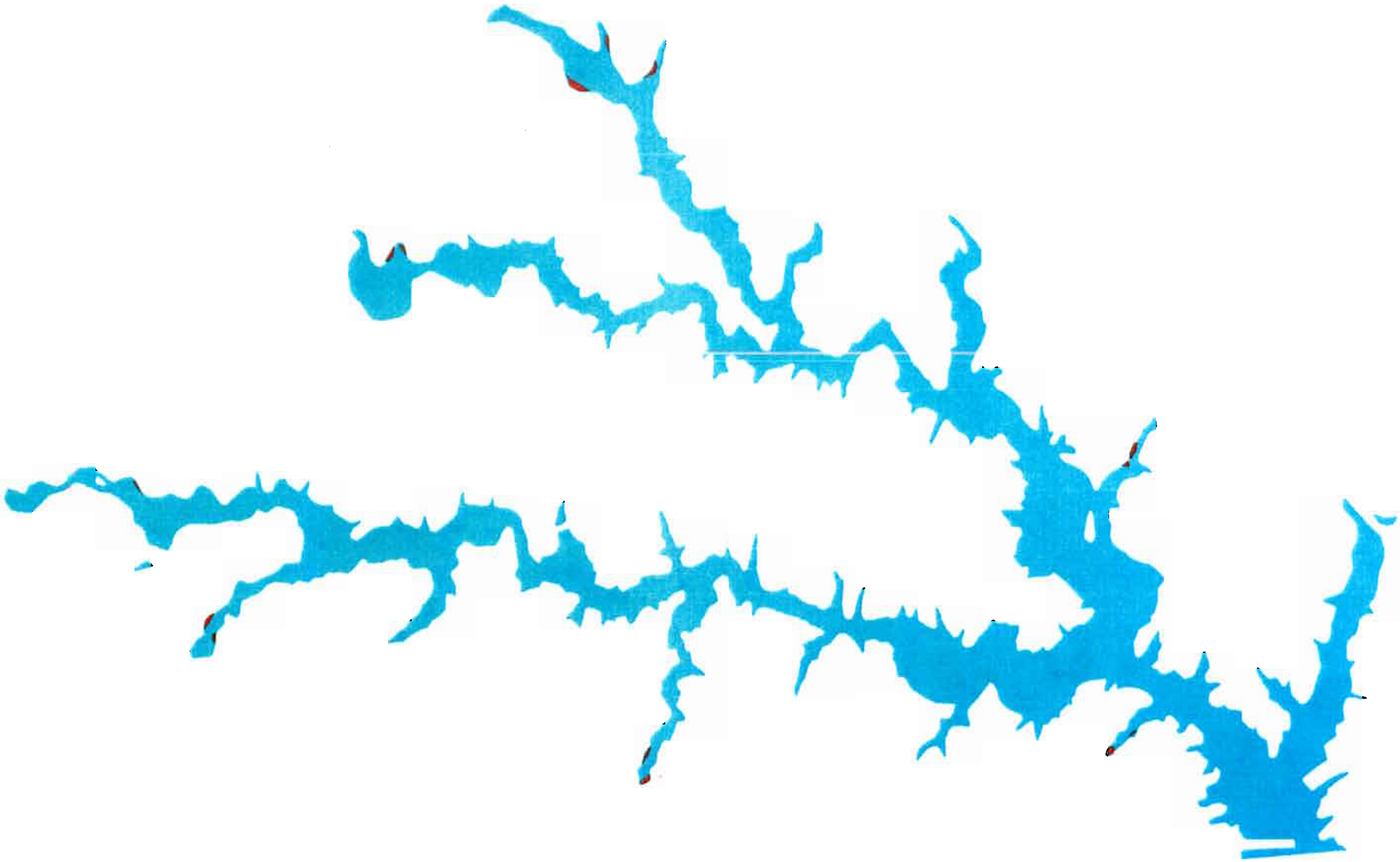

FIGURE 3.4 - 2 Lake Anna below 208 Bridge indicating hydrilla in 2000

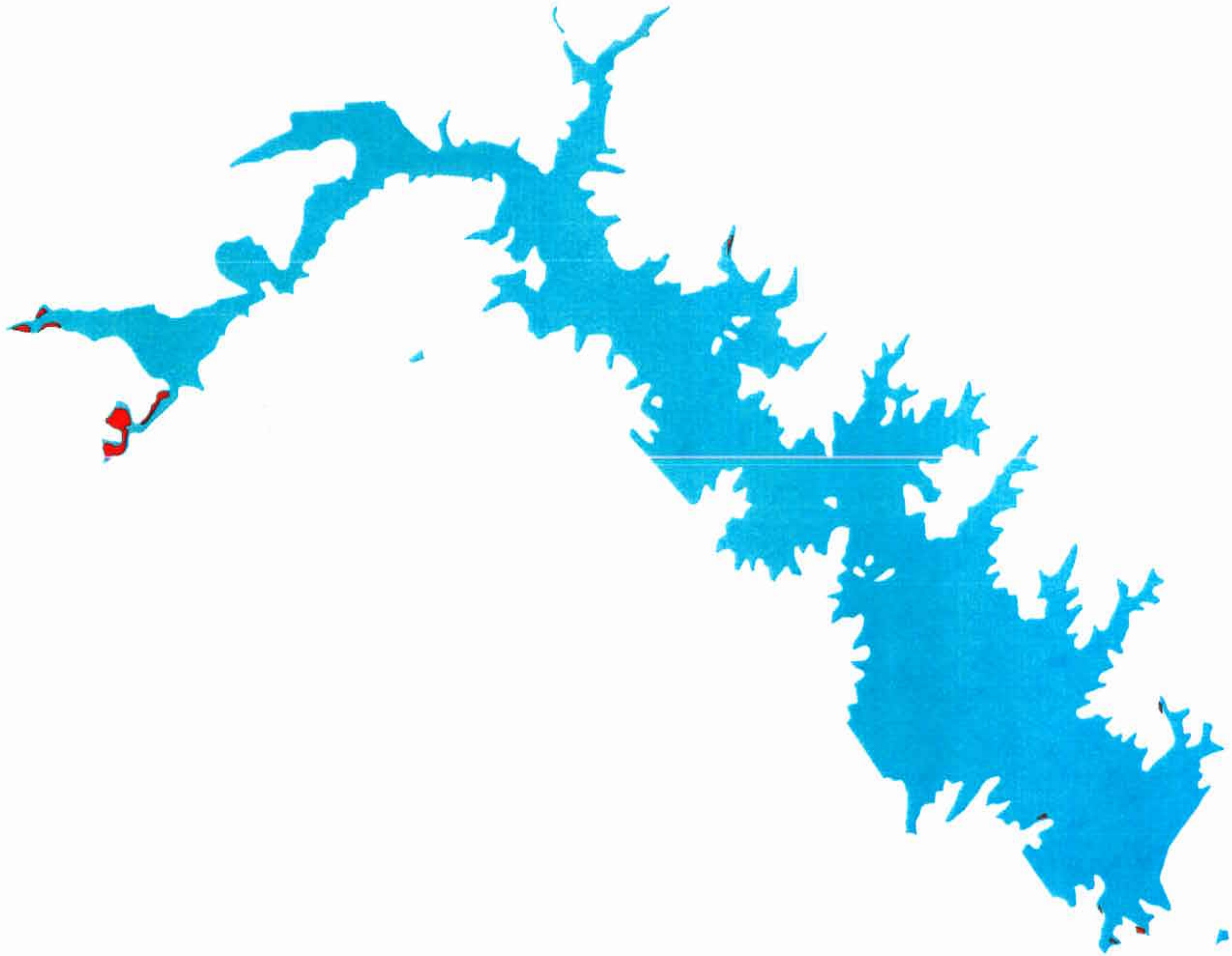

FIGURE 3.4-3 LAKE ANNA LAGOON 1 INDICATING HYDRILLA BEDS IN 2000

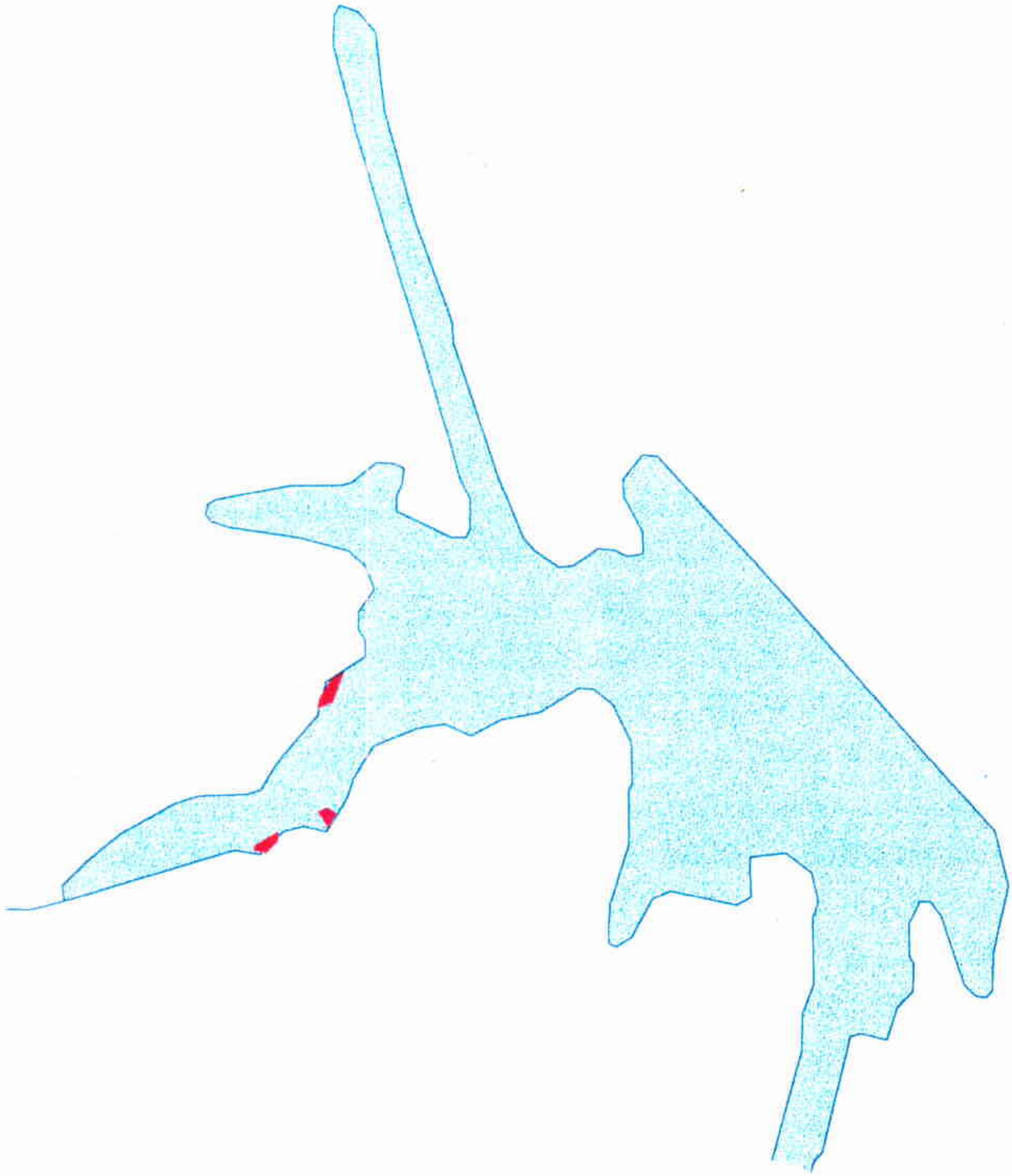

FIGURE 3.4 - 4 Lake Anna Lagoon 2 indicating hydrilla beds in 2000

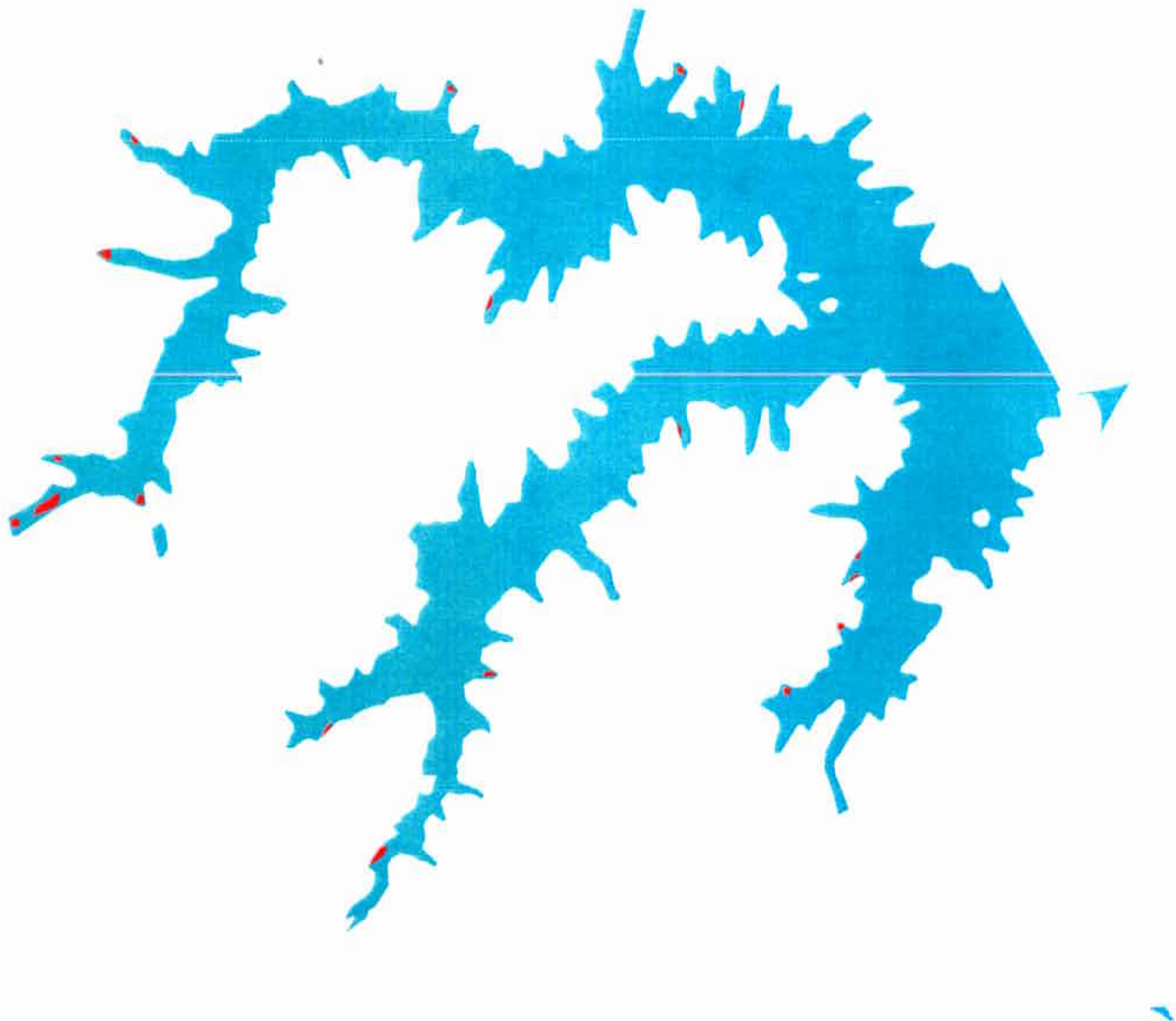

FIGURE 3.4 - 5 Lagoon 3 indicating hydrilla in 2000

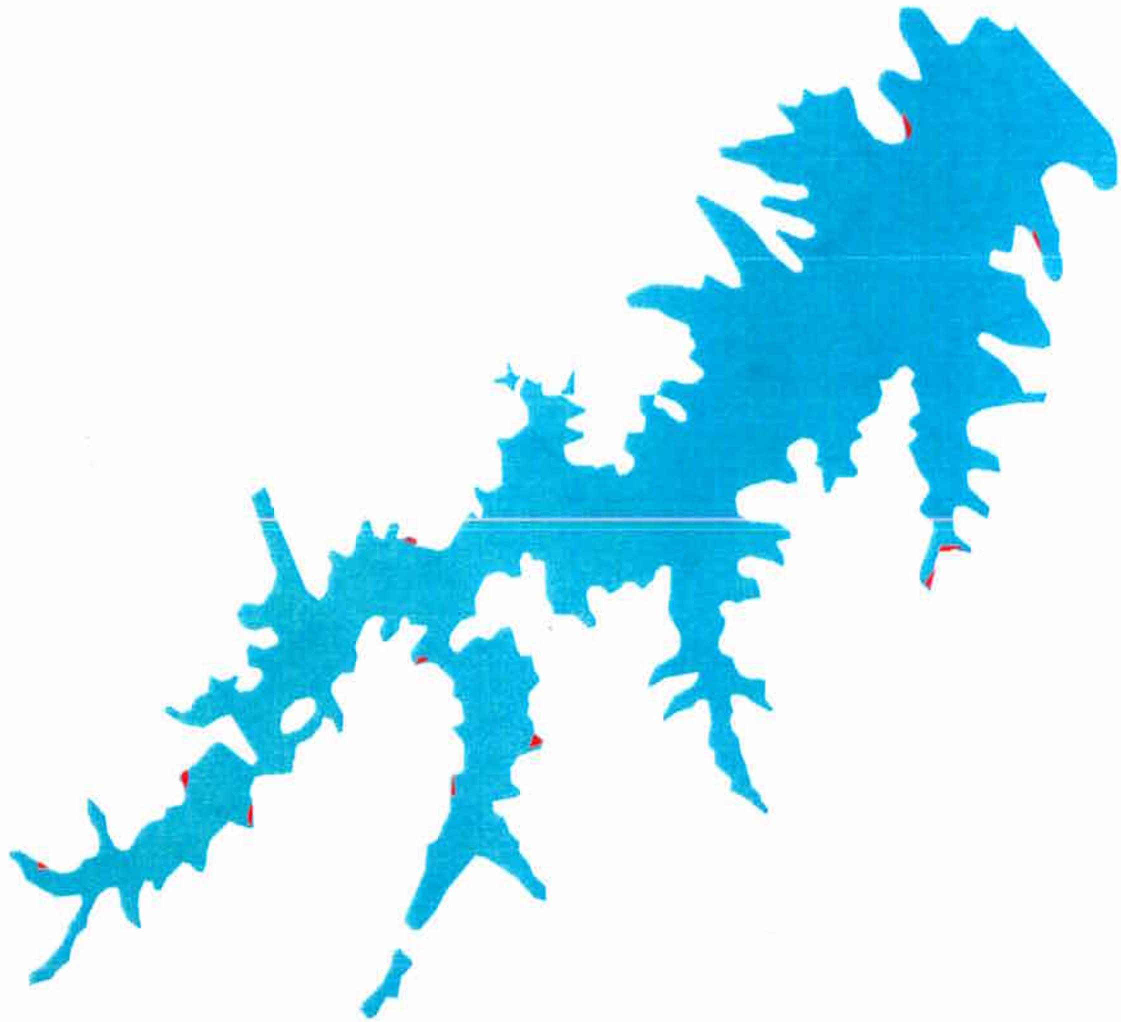

FIGURE 3.4 - 6 Acres of Hydrilla colonization in Lake Anna and the WHTF for the period 1991-2000

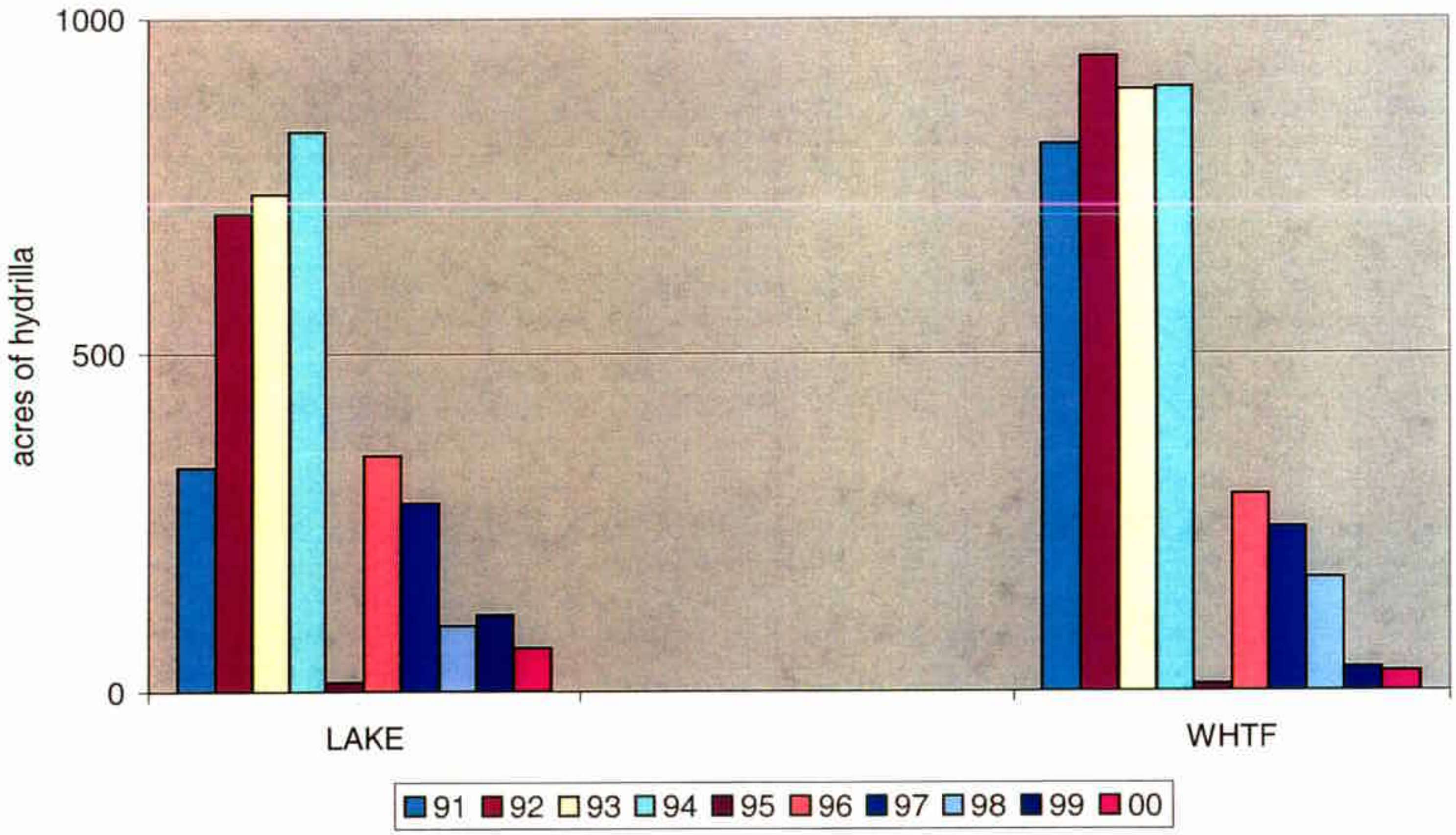

FIGURE 4.1-1 Location of North Anna River temperature recording, electrofishing, and snorkel survey stations.

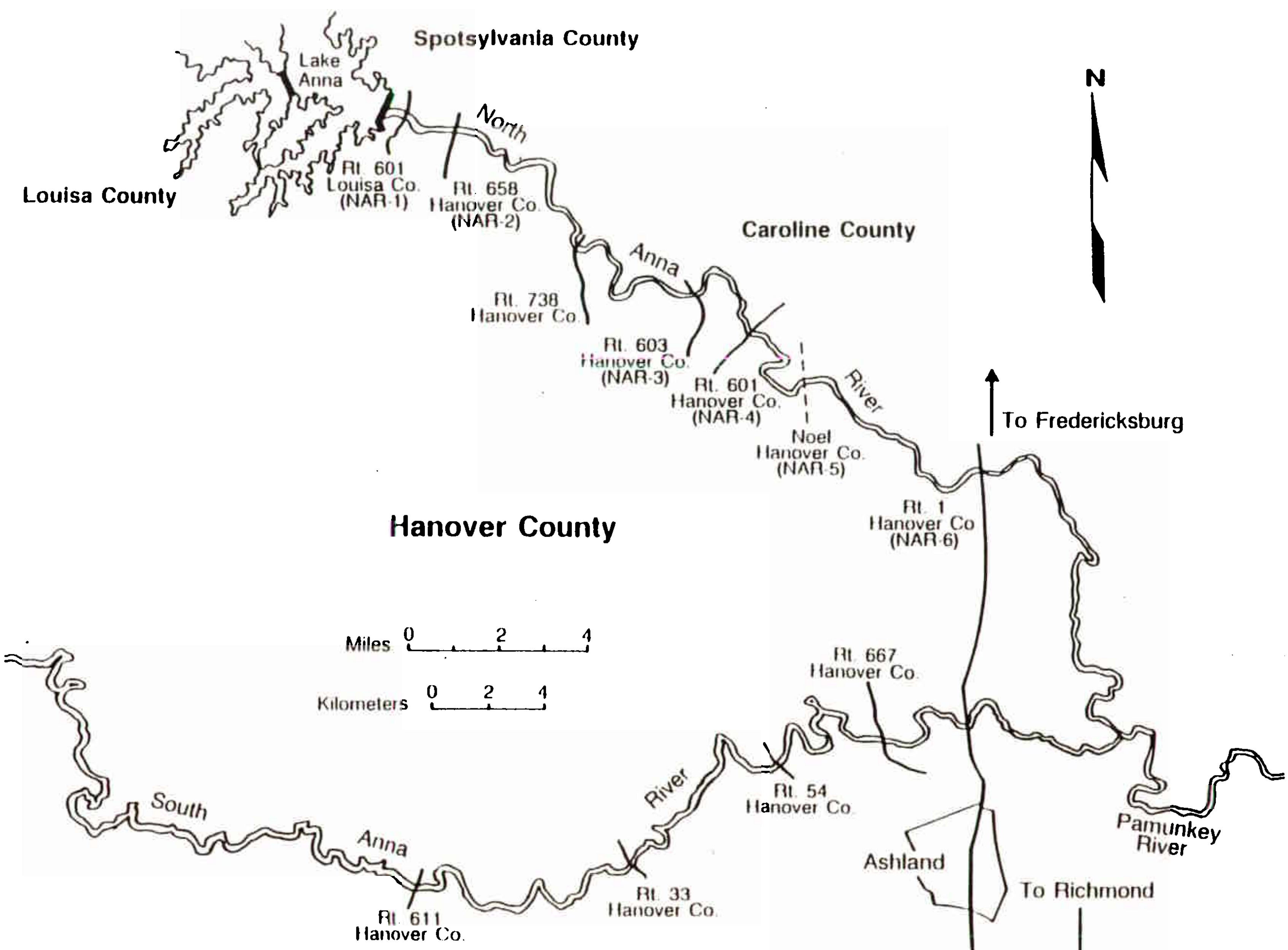

Figure 4.2-1 North Anna River Mean Monthly Streamflows 1980 - 2000

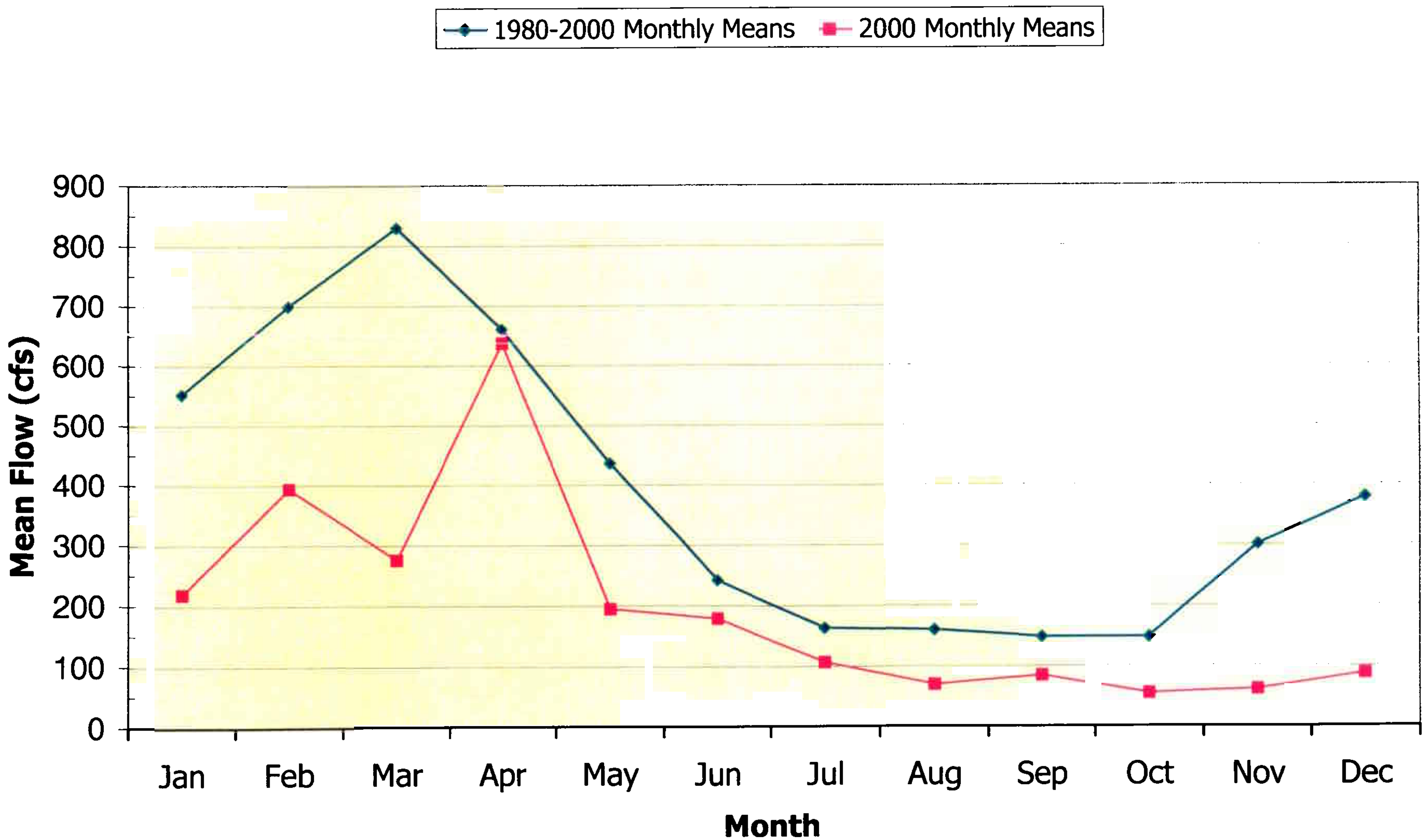

Figure 4.3-1. Number of fish collected annually from the North Anna River during electrofishing surveys, 1981-2000.

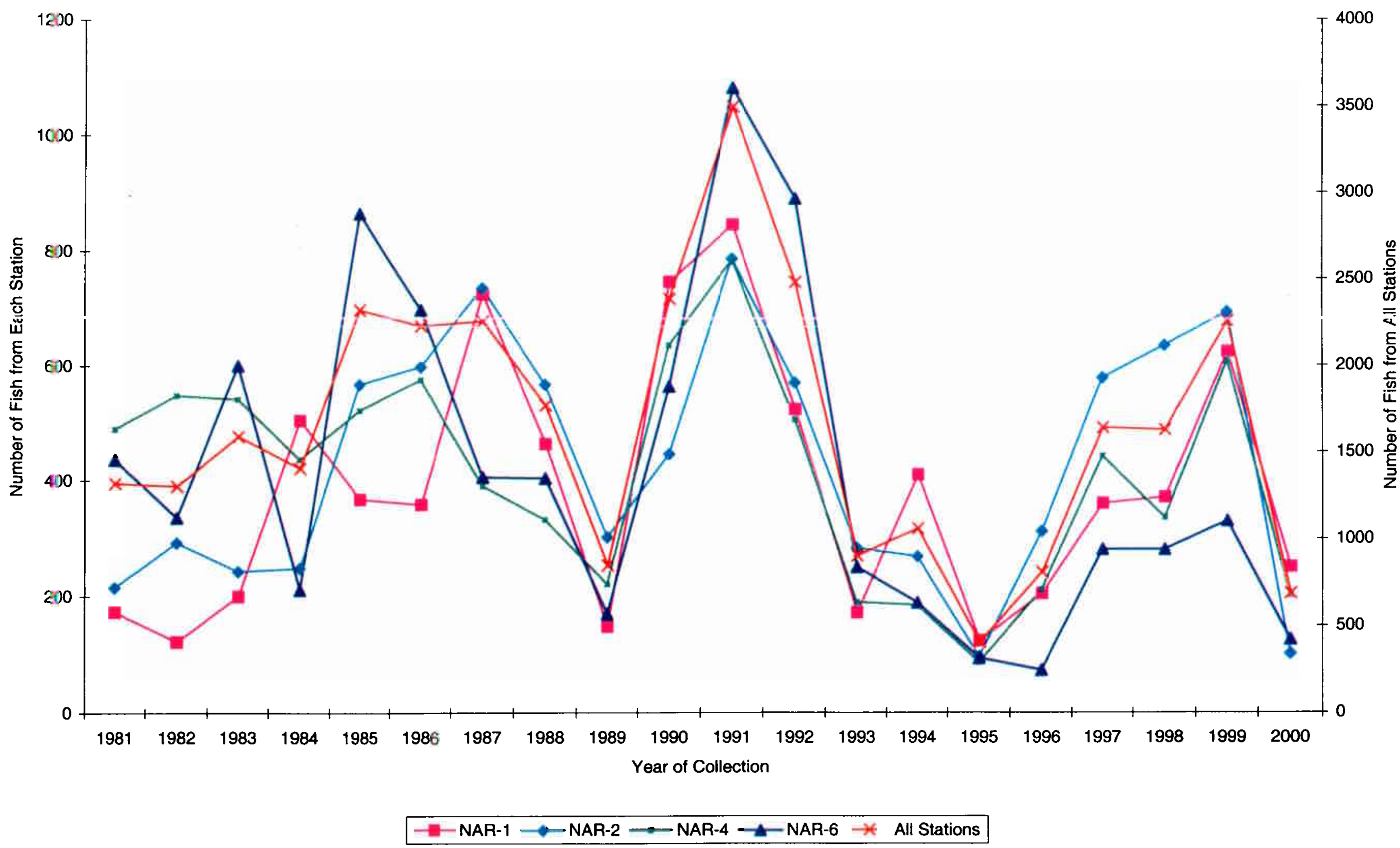

Figure 4.4-1. NAR-1 smallmouth and largemouth bass median densities, and mean visibility, 1987-2000.

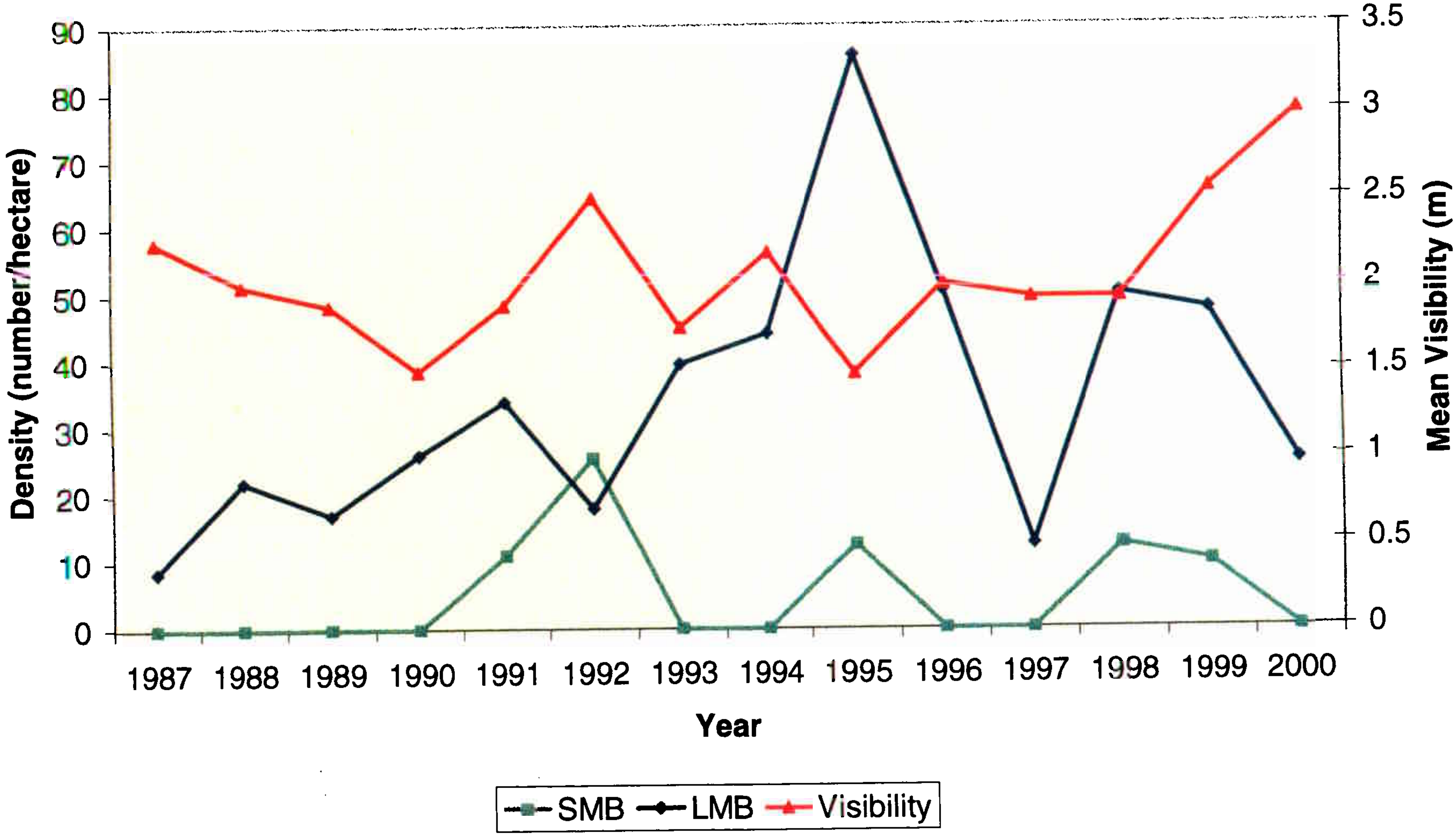

Figure 4. 4-2. NAR-2 smallmouth and largemouth bass median densities, and mean visibilities, 1987-2000.

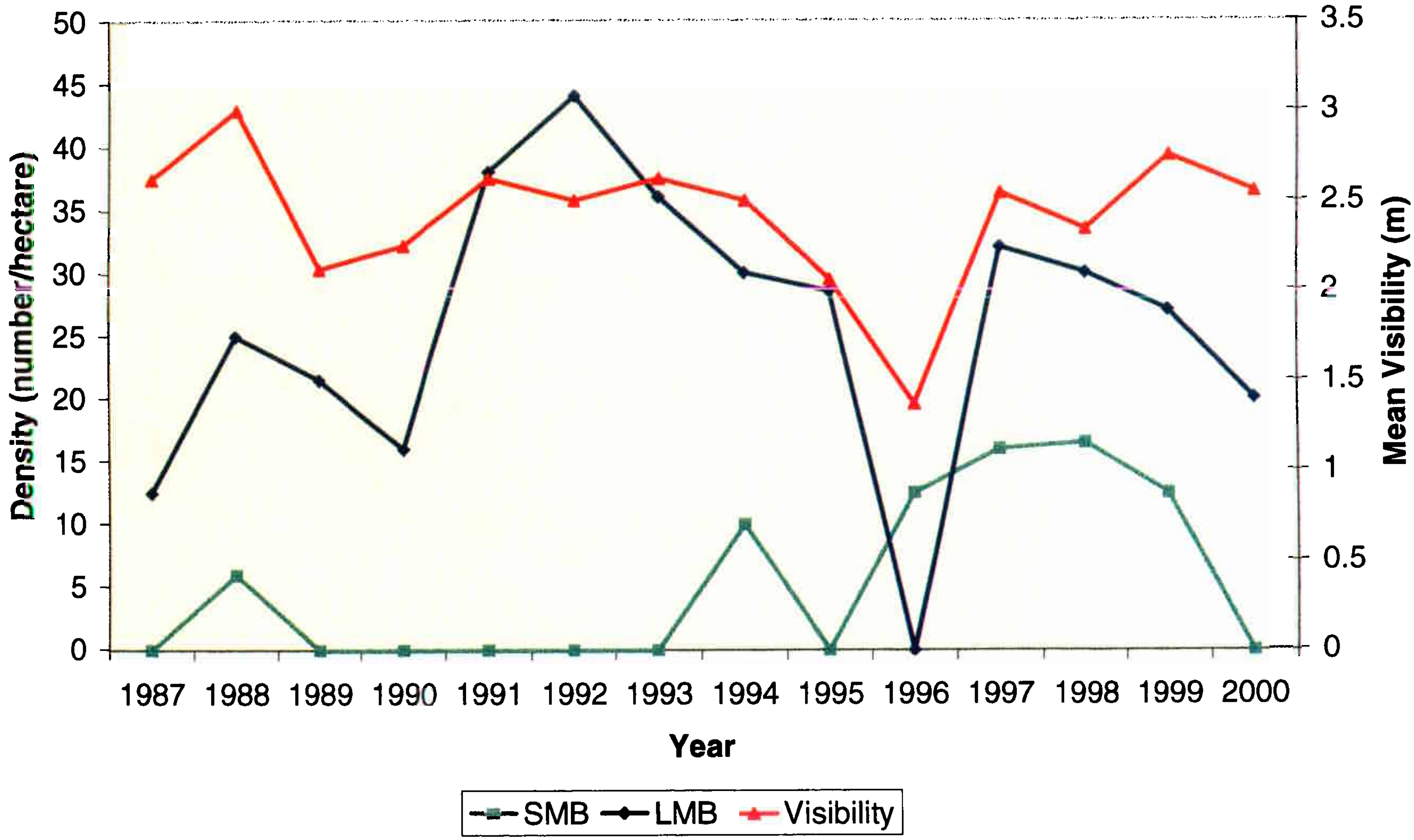

Figure 4. 4-3. NAR-4 smallmouth and largemouth bass median densities, and mean visibilities, 1987-2000.

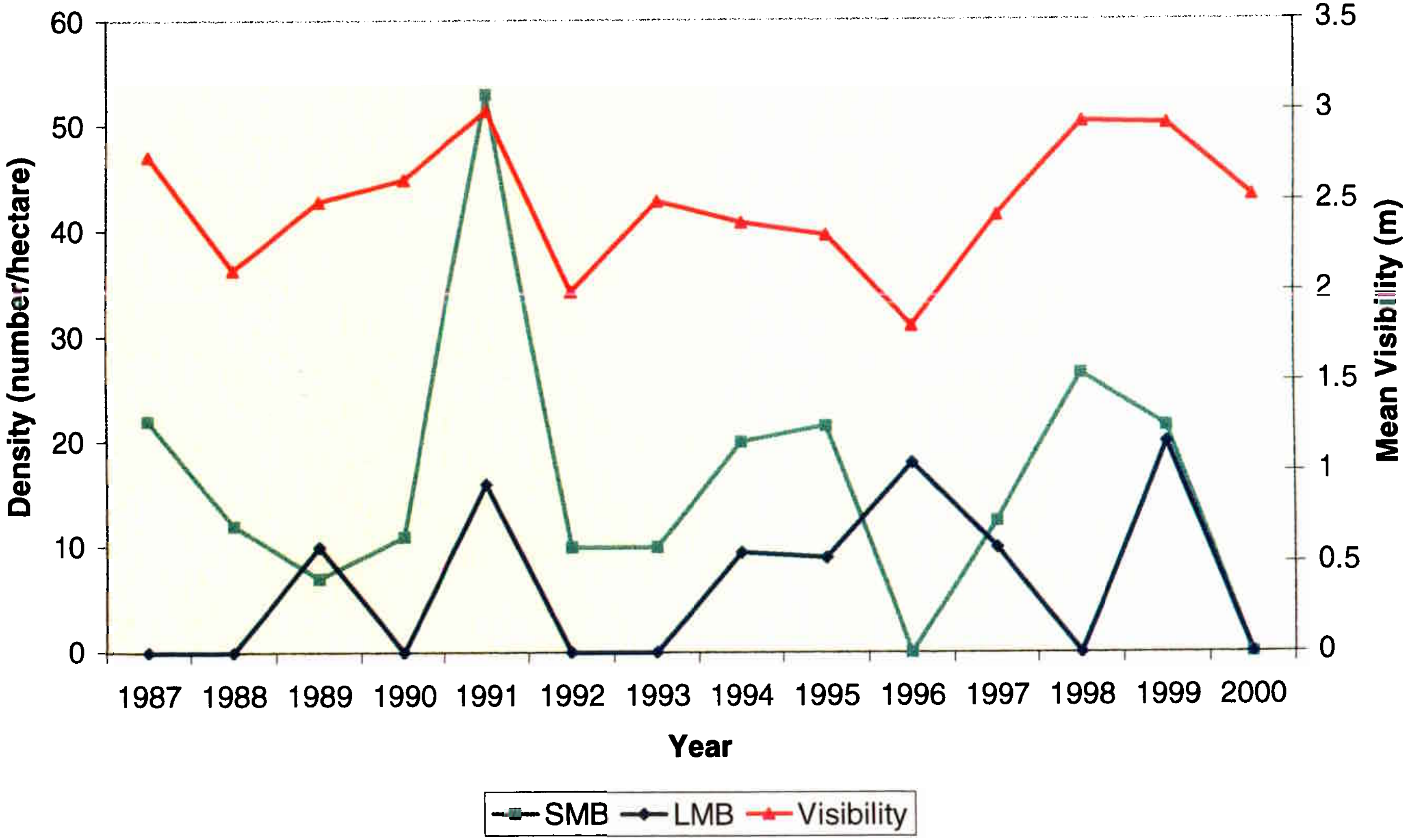

Figure 4. 4-4 . NAR-5 smallmouth and largemouth bass median densities, and mean visibilities, 1987-2000.

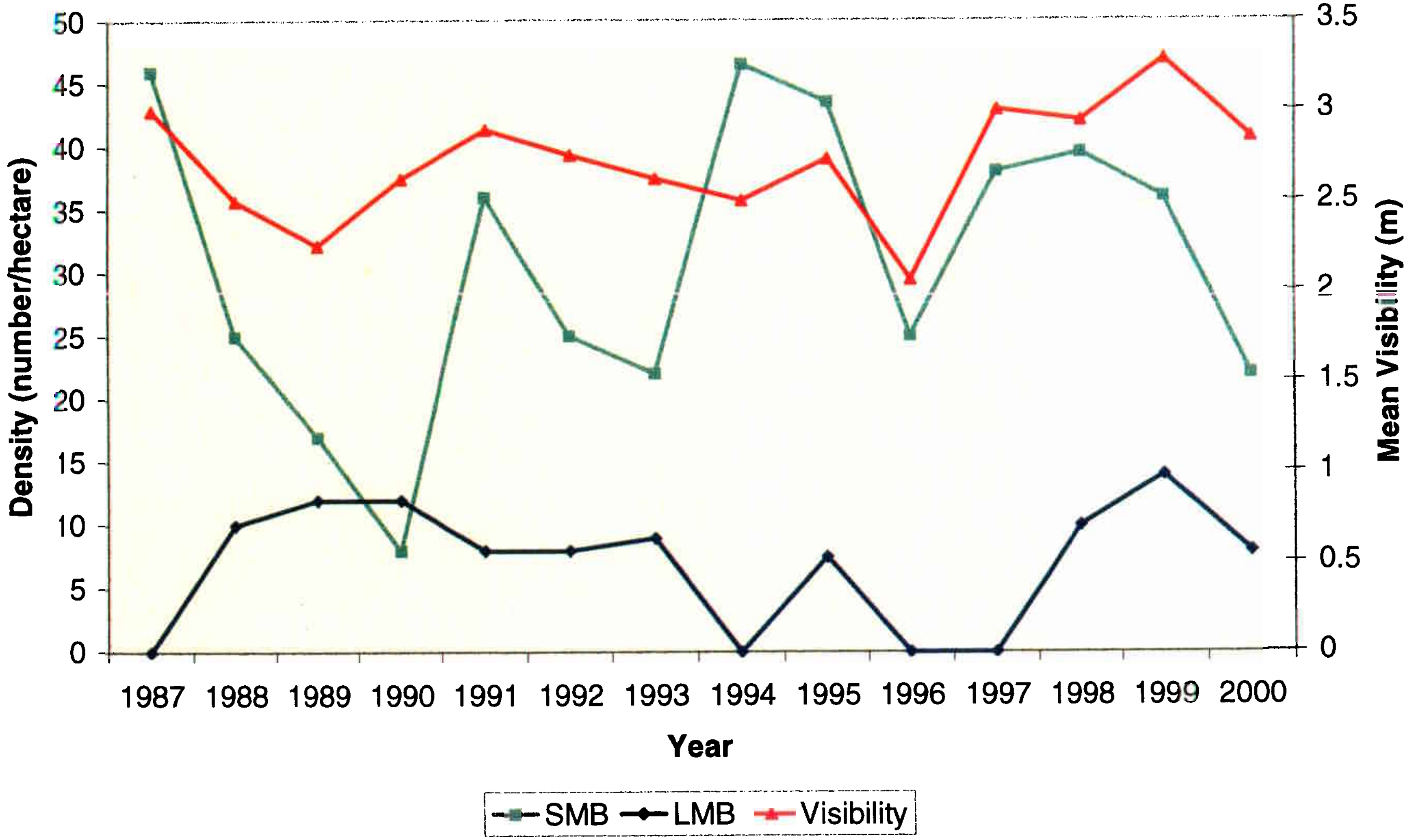

TABLE 2.0-1 Seasonal summary of North Anna Power Station operation (percent of total Station load) 1978-2000.

Year	Winter	Spring	Summer	Fall	Quarterly Average
1978	0	23	42	45	27.5
1979	43	31	44	0	29.5
1980	31	37	53	65	46.5
1981	46	80	67	82	68.8
1982	78	26	19	48	42.8
1983	53	58	96	84	72.8
1984	76	64	16	66	55.5
1985	87	96	82	62	81.8
1986	75	88	62	80	76.3
1987	92	45	23	47	51.8
1988	75	99	94	97	91.3
1989	47	26	87	65	56.3
1990	98	98	69	61	81.5
1991	63	89	84	92	82
1992	35	80	92	71	69.5
1993	49	83	79	82	73.3
1994	96	91	75	91	88.5
1995	87	64	98	97	86.5
1996	76	98	83	66	80.8
1997	98	80	97	97	93
1998	96	81	85	94	89
1999	97	90	87	93	92
2000	84	91	100	100	94
Quarters at 75-100%	14	14	13	12	

cjb/natable2.0-1/xls

TABLE 3.1-1. SUMMARY OF NORTH ANNA FIXED RECORDER TEMPERATURE DATA DURING 2000. VALUES ARE MEANS OF DAILY HIGH, MEAN AND LOW TEMPERATURES (IN DEGREES CELSIUS). ALL INSTRUMENTS ARE LOCATED AT THE SURFACE EXCEPT FOR NALST10 WHICH IS AT MID-DEPTH. "x" INDICATES DATA MISSING DUE TO INSTRUMENT MALFUNCTION OR DAMAGE. HOURS OF DATA COLLECTED ARE SHOWN.

STATION NO.	6	5	4	2	1	3	10	7	8	9	
YEAR=2000 MONTH=JANUARY											
TYPE	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
HIGH	5.6	5.6	6.9	8.0	8.0	10.2	11.0	20.7	15.7	12.7	10.2
MEAN	5.4	5.3	6.6	7.8	7.7	9.9	10.6	20.5	15.1	12.4	9.8
LOW	5.2	5.1	6.4	7.6	7.6	9.6	10.2	20.3	14.6	12.2	9.3
HOURS	743	744	743	744	614	744	743	744	744	743	744
YEAR=2000 MONTH=FEBRUARY											
TYPE	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
HIGH	6.0	5.9	5.8	7.2	7.7	9.6	10.0	18.5	15.0	12.5	9.9
MEAN	5.6	5.4	5.4	6.9	7.3	9.1	9.4	18.2	14.4	12.1	9.3
LOW	5.3	5.2	5.1	6.6	7.0	8.7	8.8	17.9	13.8	11.8	8.8
HOURS	696	696	696	696	696	696	696	696	696	696	696
YEAR=2000 MONTH=MARCH											
TYPE	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
HIGH	12.5	12.5	12.5	12.9	13.0	13.8	13.3	23.7	18.6	16.8	14.1
MEAN	11.9	11.8	12.1	12.4	12.5	13.4	12.6	23.3	18.0	16.3	13.5
LOW	11.3	11.2	11.7	12.0	12.1	13.0	11.8	22.8	17.5	15.9	13.0
HOURS	744	744	744	744	744	744	744	744	744	744	744
YEAR=2000 MONTH=APRIL											
TYPE	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
HIGH	15.9	15.6	15.3	16.1	15.5	16.5	16.0	24.6	20.9	18.8	16.3
MEAN	15.2	15.0	14.8	15.6	15.1	16.1	15.5	24.0	20.2	18.3	15.7
LOW	14.6	14.5	14.4	15.1	14.8	15.7	15.0	23.4	19.7	17.9	15.2
HOURS	719	719	719	719	719	719	718	719	719	719	718
YEAR=2000 MONTH=MAY											
TYPE	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
HIGH	24.1	24.1	23.5	21.1	23.5	23.3	20.9	30.2	28.0	26.2	23.0
MEAN	23.2	23.3	22.8	20.4	22.8	22.7	20.2	29.7	27.3	25.6	22.1
LOW	22.5	22.5	22.2	19.7	22.1	22.1	19.4	29.4	26.7	25.1	21.3
HOURS	744	744	744	744	744	744	744	744	744	744	744

TABLE 3.1-1(CONT.). SUMMARY OF NORTH ANNA FIXED RECORDER TEMPERATURE DATA DURING 2000. VALUES ARE MEANS OF DAILY HIGH, MEAN AND LOW TEMPERATURES (IN DEGREES CELSIUS). ALL INSTRUMENTS ARE LOCATED AT THE SURFACE EXCEPT FOR NALST10 WHICH IS AT MID-DEPTH. A "*" INDICATES DATA MISSING DUE TO INSTRUMENT MALFUNCTION OR DAMAGE. HOURS OF DATA COLLECTED ARE SHOWN.

STATION NO.	6	5	4	2	1	3	10	7	8	9	
YEAR=2000 MONTH=JUNE											
TYPE	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
HIGH	27.7	27.5	27.3	25.5	27.3	27.2	25.3	34.5	32.7	30.1	27.0
MEAN	26.9	26.7	26.6	24.9	26.6	26.6	24.6	34.2	32.0	29.5	26.1
LOW	26.3	26.1	26.0	24.2	26.1	26.2	23.9	33.9	31.3	29.1	25.3
HOURS	720	720	720	720	720	720	720	720	720	720	720
YEAR=2000 MONTH=JULY											
TYPE	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
HIGH	29.2	29.1	29.2	28.8	29.6	29.8	28.6	37.0	34.6	32.3	29.7
MEAN	28.6	28.4	28.7	28.3	29.1	29.3	28.0	36.8	33.9	31.6	28.6
LOW	28.1	27.9	28.3	27.8	28.6	28.9	27.5	36.6	33.2	30.7	27.7
HOURS	744	744	744	744	744	744	744	744	744	744	743
YEAR=2000 MONTH=AUGUST											
TYPE	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
HIGH	28.1	27.7	28.7	28.5	28.8	29.4	28.1	35.7	33.0	31.7	29.4
MEAN	27.6	27.2	28.2	28.0	28.3	28.9	27.6	35.5	32.4	31.3	28.4
LOW	27.2	26.8	27.8	27.7	27.9	28.6	27.2	35.3	31.8	30.9	27.6
HOURS	744	744	744	744	744	744	744	744	744	744	744
YEAR=2000 MONTH=SEPTEMBER											
TYPE	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
HIGH	24.9	26.5	27.8	26.3	27.5	27.8	27.8	32.7	32.7	29.5	28.3
MEAN	24.4	25.9	27.4	25.9	27.1	27.3	27.5	32.5	32.0	29.0	27.3
LOW	24.0	25.5	27.0	25.7	26.8	27.0	27.1	32.2	31.3	28.6	26.5
HOURS	720	720	720	720	720	720	720	720	720	720	720
YEAR=2000 MONTH=OCTOBER											
TYPE	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
HIGH	15.9	20.5	22.1	21.6	22.2	23.3	23.4	28.8	24.6	24.9	22.5
MEAN	15.4	20.0	21.7	21.2	21.8	22.9	22.9	28.4	24.0	24.5	21.6
LOW	15.0	19.5	21.3	20.9	21.5	22.6	22.5	28.1	23.4	24.2	20.9
HOURS	744	744	744	744	743	744	744	744	744	744	744

TABLE 3.1-1(CONT.). SUMMARY OF NORTH ANNA FIXED RECORDER TEMPERATURE DATA DURING 2000. VALUES ARE MEANS OF DAILY HIGH, MEAN AND LOW TEMPERATURES (IN DEGREES CELSIUS). ALL INSTRUMENTS ARE LOCATED AT THE SURFACE EXCEPT FOR NALST10 WHICH IS AT MID-DEPTH. A "*" INDICATES DATA MISSING DUE TO INSTRUMENT MALFUNCTION OR DAMAGE. HOURS OF DATA COLLECTED ARE SHOWN.

STATION NO.	6	5	4	2	1	3	10	7	8	9	
YEAR=2000 MONTH=NOVEMBER											
TYPE	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
HIGH	10.2	12.9	15.2	15.2	15.7	18.0	18.2	25.8	19.4	19.2	17.5
MEAN	9.9	12.6	14.9	15.0	15.5	17.8	17.9	25.7	19.0	19.0	17.0
LOW	9.6	12.3	14.7	14.8	15.3	17.5	17.6	25.5	18.6	18.7	16.2
HOURS	720	720	720	720	720	720	720	720	720	720	720
YEAR=2000 MONTH=DECEMBER											
TYPE	NAL719ST	NAL719NT	NAL208T	NALINT	NALTHIST	NALBRPTT	NALST10	NADISC1	NAWHTF2	NAWHTF3	NARIV601
HIGH	4.8	5.2	8.2	9.0	8.6	13.4	12.2	21.9	14.8	13.9	11.8
MEAN	4.6	5.0	7.9	8.9	8.4	13.1	12.0	21.7	14.3	13.6	11.4
LOW	4.4	4.8	7.7	8.7	8.2	12.8	11.7	21.5	13.9	13.4	10.8
HOURS	744	744	744	744	744	744	744	744	744	744	744

TABLE 3.1-2. NORTH ANNA LAKE SURVEY SHOWING TEMPERATURES (IN CELSIUS DEGREES) MEASURED AT ONE METER INTERVAL DEPTHS FOR STATIONS IN LAKE ANNA.

		STATION													
DATE	DEPTH (M)	A	B	C	D	E	F	G	H	I	J	K	L	M	N
02/10/2000	0	9.1	9.1	8.8	8.8	8.9	8.3	8.1	7.1	6.7	5.8	4.1	4.7		
	1	9.1	9.1	8.6	8.7	8.8	8.2	8.0	6.9	6.5	5.7	4.0	4.6		
	2	9.0	9.0	8.5	8.6	8.8	8.1	7.8	6.8	6.3	5.7	4.0	4.4		
	3	8.9	8.8	8.3	8.5	8.6	8.0	7.7	6.7	6.2	5.6	4.0	4.3		
	4	8.9	8.7	8.0	8.3	8.3	7.0	7.6	6.5	6.1	5.5	3.9	4.2		
	5	8.9	8.6	8.0	8.0	7.9	7.8	7.6	6.3	6.0	5.5	3.9	4.1		
	6	8.9	8.5	7.8	7.8	7.7	7.8	7.6	6.0	5.9	5.4	3.9	4.1		
	7	8.9	8.5	7.7	7.7	7.6	7.7	7.5	5.9	5.9	5.4	3.9	4.0		
	8	8.8	8.5	7.6	7.6	7.6	7.6	7.4	5.8	5.9	5.4	3.9			
	9	8.7	8.4	7.5	7.5	7.5	7.6	7.3	5.8	5.8	5.3	3.9			
	10	7.5	8.3	7.4	7.4	7.5	7.4	7.1	5.7	5.6	5.1	3.9			
	11	7.3	7.9	7.3	7.3	7.3	7.1	6.9	5.6	5.5	5.0	3.9			
	12	7.1	7.8	7.1	7.2	7.2	6.8	6.7	5.5	5.3	4.8	3.9			
	13	7.0	7.7	7.1	7.1	7.1	6.6	6.6	5.3	5.0	4.7	3.9			
	14	6.9	7.5	7.0	7.0	7.1	6.4	6.3	5.2		4.7				
	15	6.8	7.5	7.0	7.0	7.0	6.4	6.1	5.1						
	16	6.8	7.5	6.8	6.9	6.9	6.4	6.0							
	17	6.8		6.8	6.8	6.8	6.3	5.9							
	18	6.7		6.8	6.8	6.8	6.3	5.9							
	19	6.7		6.8	6.7		6.2	5.9							
	20	6.7					6.2								
	21	6.7													

TABLE 3.1-2(CONT.). NORTH ANNA LAKE SURVEY SHOWING TEMPERATURES (IN CELSIUS DEGREES) MEASURED AT ONE METER INTERVAL DEPTHS FOR STATIONS IN LAKE ANNA.

		STATION													
DATE	DEPTH (M)	A	B	C	D	E	F	G	H	I	J	K	L	M	N
06/13/2000	0	27.4	27.3	26.9	29.4	27.1	27.5	27.7	28.0	28.7	28.5	29.2	27.6	28.0	27.9
	1	27.1	27.3	26.7	27.1	26.9	27.4	27.5	27.9	28.5	28.3	28.0	27.5	27.9	27.8
	2	26.9	27.0	26.6	26.9	26.8	27.3	27.2	27.6	28.4	28.2	27.7	27.3	27.5	27.3
	3	26.7	26.5	26.3	26.6	26.7	27.2	26.8	27.3	28.1	26.5	26.4	26.1	26.5	25.5
	4	26.5	25.6	25.7	26.2	26.4	27.0	26.1	24.8	25.6	25.5	25.7	24.6	24.6	24.4
	5	26.3	24.4	25.3	25.6	26.1	26.6	25.7	24.4	24.6	25.0	24.8	23.8	23.8	23.3
	6	25.8	24.1	25.2	25.5	26.0	26.2	25.4	24.1	24.0	24.1	24.1	23.4	22.9	23.1
	7	25.3	23.7	24.8	25.0	25.4	25.4	24.6	23.4	23.5	23.6	23.2	23.2	22.4	23.0
	8	24.4	23.3	24.5	24.6	24.6	24.5	23.6	23.2	23.1	23.5	22.9		22.3	
	9	23.6	22.4	24.1	23.6	24.1	23.8	20.4	23.2	22.8	22.8	22.5			
	10	20.2	19.7	20.9	21.0	21.4	20.9	20.8	20.2	20.4	20.5	20.2			
	11	19.8	19.3	20.5	20.5	20.7	20.4	20.1	19.9	20.1	19.7	20.0			
	12	19.6	19.1	20.0	19.9	20.5	19.9	19.7	19.6	19.8	19.4	19.6			
	13	18.7	19.0	19.7	19.5	20.2	19.5	19.3	19.5	19.6	19.4	19.6			
	14	18.2	19.0	19.4	19.1	19.4	19.2	19.0	19.5		19.2	19.6			
	15	17.9	19.0	19.0	18.7	19.1	19.0	18.7	19.6						
	16	17.6	19.0	18.5	18.2	18.5	18.7	18.5							
	17	15.8		17.8	17.2	18.4	18.1	18.0							
	18	15.0		16.9	16.2	18.4	17.3	17.4							
	19	14.7		16.0	16.2		16.8	16.2							
	20	14.4					16.8								
	21	14.4													

TABLE 3.1-2(CONT.). NORTH ANNA LAKE SURVEY SHOWING TEMPERATURES (IN CELSIUS DEGREES) MEASURED AT ONE METER INTERVAL DEPTHS FOR STATIONS IN LAKE ANNA.

		STATION													
DATE	DEPTH (M)	A	B	C	D	E	F	G	H	I	J	K	L	M	N
08/22/2000	0	28.4	28.4	28.4	28.2	28.2	28.0	27.9	27.6	27.3	27.1	26.8	26.4	26.5	27.1
	1	28.4	28.4	28.4	28.2	28.2	28.0	27.9	27.6	27.3	27.1	26.9	26.5	26.5	26.9
	2	28.4	28.5	28.4	28.3	28.2	28.0	27.9	27.6	27.3	27.1	26.9	26.4	26.4	26.6
	3	28.4	28.5	28.4	28.3	28.2	28.0	27.9	27.6	27.3	27.1	26.9	26.4	26.2	26.4
	4	28.4	28.5	28.2	28.2	28.1	28.0	27.8	27.5	27.2	27.1	26.9	26.3	26.2	26.2
	5	28.4	28.5	28.1	28.1	28.0	27.9	27.8	27.4	27.2	27.1	26.8	26.3	26.1	26.1
	6	28.4	28.4	27.9	28.0	28.0	27.9	27.8	27.3	27.2	27.1	26.9	26.3	26.1	26.0
	7	28.4	28.3	27.9	27.9	27.9	27.9	27.8	27.2	27.2	27.1	26.8	26.3	26.1	26.0
	8	28.4	28.1	27.8	27.8	27.9	27.9	27.8	27.1	27.2	27.0	26.8		26.1	
	9	28.4	28.1	27.8	27.8	27.9	27.8	27.7	27.0	27.1	27.0	26.6			
	10	28.0	27.9	27.8	27.7	27.9	27.8	27.6	27.0	27.1	27.0	26.5			
	11	27.9	27.7	27.7	27.7	27.8	27.7	27.5	26.9	27.1	27.0	26.5			
	12	27.7	27.2	27.6	27.7	27.8	27.5	27.4	26.9	27.1	26.9	26.5			
	13	27.5	27.1	27.6	27.6	27.6	27.4	27.3	26.8	26.9	26.7				
	14	27.3	27.0	27.5	27.4	27.3	27.4	27.2	26.8		26.6				
	15	26.9	27.0	27.3	27.1	27.1	27.3	27.1	26.7						
	16	26.6	26.9	27.1	26.7	26.8	26.8	26.8							
	17	25.8		26.1	26.1	26.6	26.7	26.5							
	18	24.9		25.5	24.9	26.3	26.4	26.2							
	19	24.4		25.0	24.1		26.2	26.1							
	20	22.5					26.2								
	21	19.7													

TABLE 3.1-2(CONT.). NORTH ANNA LAKE SURVEY SHOWING TEMPERATURES (IN CELSIUS DEGREES) MEASURED AT ONE METER INTERVAL DEPTHS FOR STATIONS IN LAKE ANNA.

		STATION													
DATE	DEPTH (M)	A	B	C	D	E	F	G	H	I	J	K	L	M	N
11/17/2000	0	17.7	18.1	17.6	17.6	17.5	16.7	16.3	16.1	15.8	15.7	14.8	14.1	13.1	13.1
	1	17.7	18.1	17.6	17.6	17.4	16.7	16.3	16.1	15.8	15.7	14.8	14.1	13.1	13.1
	2	17.7	18.1	17.6	17.6	17.4	16.7	16.3	16.1	15.8	15.7	14.8	14.0	13.1	13.0
	3	17.7	18.1	17.6	17.6	17.4	16.7	16.3	16.1	15.8	15.7	14.8	14.0	13.0	12.9
	4	17.7	18.1	17.6	17.6	17.4	16.7	16.3	16.1	15.8	15.7	14.8	13.9	12.9	12.8
	5	17.7	18.1	17.6	17.6	17.4	16.7	16.3	16.1	15.8	15.7	14.8	13.9	12.9	12.7
	6	17.7	18.1	17.6	17.6	17.4	16.7	16.3	16.1	15.8	15.6	14.8	13.8	12.8	12.7
	7	17.7	18.1	17.5	17.4	17.4	16.7	16.3	16.0	15.8	15.6	14.8	13.8	12.8	12.6
	8	17.7	18.1	17.5	17.3	17.4	16.7	16.2	15.9	15.8	15.6	14.8			
	9	17.7	18.1	17.4	17.2	17.2	16.6	16.2	15.9	15.7	15.6	14.7			
	10	17.7	18.1	17.3	17.2	17.1	16.6	16.2	15.9	15.7	15.6	14.7			
	11	17.7	18.1	17.1	17.1	17.1	16.6	16.2	15.9	15.7	15.5	14.6			
	12	17.7	18.1	17.1	17.1	17.1	16.6	16.2	15.8	15.7	15.4	14.6			
	13	17.7	18.1	17.0	17.0	17.0	16.5	16.1	15.8	15.7	15.2	14.6			
	14	17.6	18.1	17.0	17.0	17.0	16.5	16.1	15.8		15.2	14.5			
	15	17.6	18.0	17.0	17.0	17.0	16.4	16.1	15.8			14.5			
	16	17.5	18.0	17.0	16.9	16.9	16.4	16.0							
	17	17.4		17.0	16.9	16.9	16.4	16.0							
	18	17.4		17.0	16.9	16.9	16.4	15.9							
	19	17.4		17.0	16.9		16.4	15.9							
	20	17.4					16.4								
	21	17.4													

TABLE 3.2- 1 Surface water temperature (C), conductivity (umhos),pH (standard units) and dissolved oxygen (mg/l) recorded at time of sampling during 2000

FEBRUARY

Station	Temperature	Conductivity	pH	Dissolved Oxygen
Electrofish Stations				
Dike 1 WHTF	18	52	6	9
Dike 3 WHTF	13	51	6	8
Lagoon 1	17	52	6	9
Lagoon 3	13	51	6	8
North Anna Arm	8	64	6	13
Thurman Island	9	50	8	10
Dike 1 Lake	9	50	7	10
Dike 3 Lake	11	51	7	9
Lower Lake Cove	11	51	7	9
Gillneting Stations				
Lagoon 1	19	51	7	9
Lagoon 3	14	51	6	9
North Anna Arm	8	65	6	13
Thurman Island	9	50	7	11
Levy Creek	11	51	7	10
Lower Lake	12	51	7	9

MAY

Station	Temperature	Conductivity	pH	Dissolved Oxygen
Electrofish Stations				
Dike 1 WHTF	27	46	7	9
Dike 3 WHTF	29	47	7	8
Lagoon 1	28	47	7	8
Lagoon 3	28	47	7	9
North Anna Arm	26	49	8	11
Thurman Island	26	45	8	8
Dike 1 Lake	22	45	7	8
Dike 3 Lake	22	45	7	8
Lower Lake Cove	23	45	7	9
Gillneting Stations				
Lagoon 1	27	47	7	8
Lagoon 3	27	46	7	8
North Anna Arm	26	51	8	11
Thurman Island	24	45	8	9
Levy Creek	23	46	7	9
Lower Lake	22	46	7	8

AUGUST

Station	Temperature	Conductivity	pH	Dissolved Oxygen
Electrofish Stations				
Dike 1 WHTF	36	47	7	7
Dike 3 WHTF	32	46	7	7
Lagoon 1	36	46	7	7
Lagoon 3	32	45	8	7
North Anna Arm	31	66	8	9
Thurman Island	31	60	8	8
Dike 1 Lake	30	61	8	8
Dike 3 Lake	30	61	7	6
Lower Lake Cove	32	61	8	8
Gillneting Stations				
Lagoon 1	36	61	7	6
Lagoon 3	32	61	8	7
North Anna Arm	31	67	8	9
Thurman Island	32	61	8	8
Levy Creek	31	61	7	7
Lower Lake	31	61	8	7

OCTOBER

Station	Temperature	Conductivity	pH	Dissolved Oxygen
Electrofish Stations				
Dike 1 WHTF	26	48	7	9
Dike 3 WHTF	20	51	7	9
Lagoon 1	25	48	7	9
Lagoon 3	20	49	7	9
North Anna Arm	13	50	7	11
Thurman Island	16	45	7	9
Dike 1 Lake	16	43	7	9
Dike 3 Lake	18	44	7	8
Lower Lake Cove	17	44	7	9
Gillneting Stations				
Lagoon 1	27	47	7	9
Lagoon 3	21	47	7	9
North Anna Arm	13	46	7	11
Thurman Island	16	45	7	10
Levy Creek	18	44	7	9
Lower Lake	19	44	7	9

Table 3.2-2. Fishes collected in Lake Anna and the WHTF by gill netting in 2000

FAMILY	SPECIES	LAKE	WHTF
Clupeidae	Dorosoma cepedianum	X	X
	Dorosoma petenense	X	X
Cyprinidae	Cyprinella analostana	X	
	Cyprinus carpio	X	X
Catostomidae	Erimyzon oblongus	X	
Ictaluridae	Ameiurus catus	X	X
	Ameiurus natalis	X	
	Ictalurus punctatus	X	X
Moronidae	Morone americana	X	X
	Morone saxatilis	X	X
Centrarchidae	Lepomis auritus	X	
	Lepomis macrochirus	X	
	Lepomis microlophus	X	X
	Micropterus salmoides	X	X
	Pomoxis nigromaculatus	X	
Percidae	Stizostedion vitreum	X	X

NA01X35q

TABLE 3.2-3 NUMBER AND WEIGHT (g) OF FISHES BY STATION COLLECTED BY GILL NETTING AT LAKE ANNA DURING 2000

STATION		FEBRUARY	MAY	AUGUST	OCTOBER	TOTAL	CPUE
LAGOON 1							
	NUMBER	27	19	32	28	106	26.5
	WEIGHT	15666	8857	10320	17906	52749	13187.25
LAGOON 3							
	NUMBER	15	24	20	10	69	17.25
	WEIGHT	5560	10058	5730	3845	25193	6298.25
LEVY CREEK							
	NUMBER	36	16	28	11	91	22.75
	WEIGHT	36614	5614	5372	2781	50381	12595.25
LOWER LAKE							
	NUMBER	28	6	20	16	70	17.5
	WEIGHT	17353	2049	6567	7013	32982	8245.5
NORTH ANNA ARM							
	NUMBER	98	74	46	78	296	74
	WEIGHT	17555	22411	17567	24697	82230	20557.5
THURMAN ISLAND							
	NUMBER	14	29	18	17	78	19.5
	WEIGHT	16123	17006	5065	6278	44472	11118
TOTALS							
	NUMBER	218	168	164	160	710	29.6
	WEIGHT	108871	65995	50621	62520	288007	12000.3

TABLE 3.2-4 GILL NET SUMMARY 2000

GILL NET - LAKE

STATION:ALL STATIONS	FEBRUARY		MAY		AUGUST		OCTOBER		TOTALS		% OF TOTAL	
SPECIES	NUMBER	WEIGHT	NUMBER	WEIGHT	NUMBER	WEIGHT	NUMBER	WEIGHT	NUMBER	WEIGHT	NUMBER	WEIGHT
D. cepedianum	39	3372	52	13416	68	12786	36	8329	195	37903	36	18
M. saxatilis	44	49705	13	9184			16	16225	73	75114	14	36
P. nigromaculatus	37	5901	19	1967	8	653	8	1178	72	9698	13	5
M. americana	21	5935	10	790	3	240	32	1877	66	8842	12	4
I. punctatus	10	7011	10	9094	14	9933	12	4246	46	30284	9	14
A. catus	11	3008	14	3957	2	182	3	850	30	7996	6	4
S. vitreum	6	5530			1	1324	6	4656	13	11510	2	5
M. salmoides	5	3866	3	1914	5	1220			13	7000	2	3
D. petenense					5	41	4	29	9	69	2	0
C. carpio	1	2990	2	6727	4	8135	2	2570	9	20421	2	10
L. microlophus	1	250					2	542	3	792	1	0
L. macrochirus			1	24	1	5			2	29	0	0
L. auritus					1	54			1	54	0	0
E. oblongus	1	78							1	78	0	0
C. analostana			1	11					1	11	0	0
A. natalis							1	266	1	266	0	0
Total No.	176		125		112		122		535		100	
Total Wt.	87645		47082		34572		40769		210068		100	

GILL NET TOTALS - WHTF

STATION:ALL STATIONS	FEBRUARY		MAY		AUGUST		NOVEMBER		TOTALS		% OF TOTAL	
SPECIES	NUMBER	WEIGHT	NUMBER	WEIGHT	NUMBER	WEIGHT	NUMBER	WEIGHT	NUMBER	WEIGHT	NUMBER	WEIGHT
D. cepedianum	12	4508	19	7455	21	7143	7	3004	59	22110	34	28
I. punctatus	18	5580	6	1197	3	973	8	1529	35	9280	20	12
A. catus	5	2082	1	286	17	5163	1	272	24	7804	14	10
M. americana	2	314	5	220	1	60	10	853	18	1446	10	2
M. salmoides	2	859	1	193	6	2114	3	1376	12	4542	7	6
D. petenense			8	4913					8	4913	5	6
C. carpio	2	7569	1	4127			4	12000	7	23696	4	30
L. microlophus			1	323	4	595	1	7	6	925	3	1
M. saxatilis			1	201			4	2711	5	2912	3	4
S. vitreum	1	314							1	314	1	0
Total No.	41		43		52		38		175		100	
Total Wt.	21226		18914		16049		21751		77940		100	

Table 3.3-1. Fishes collected in Lake Anna and the WHTF by electrofishing in 2000

FAMILY	SPECIES	LAKE	WHTF
Clupeidae	Dorosoma cepedianum	X	
Cyprinidae	Cyprinella analostana	X	X
	Cyprinus carpio	X	X
	Notropis hudsonius	X	
	Notropis procne	X	X
Catostomidae	Erimyzon oblongus	X	
Ictaluridae	Ameiurus catus	X	X
	Ameiurus natalis		X
	Ameiurus nebulosus	X	X
	Ictalurus punctatus		X
Poeciliidae	Gambusia affinis	X	
Moronidae	Morone americana	X	
Centrarchidae	Lepomis auritus	X	X
	Lepomis cyanellus	X	X
	Lepomis gibbosus	X	
	Lepomis gulosus	X	X
	Lepomis macrochirus	X	X
	Lepomis microlophus	X	X
	Micropterus salmoides	X	X
	Pomoxis nigromaculatus	X	
Percidae	Perca flavescens	X	

NA01X356

TABLE 3.3-2 NUMBER AND WEIGHT (g) OF FISHES BY STATION COLLECTED BY ELECTROFISHING AT LAKE ANNA DURING 2000

STATION		FEBRUARY	MAY	AUGUST	OCTOBER	TOTAL	CPUE
LAGOON 1	NUMBER	71	41	42	127	281	70.25
	WEIGHT	554	2362	675	2447	6038	1509.5
LAGOON 3	NUMBER	59	61	46	107	273	68.25
	WEIGHT	232	965	1395	315	2907	726.75
DIKE 1-WHTF	NUMBER	594	130	98	693	1515	378.75
	WEIGHT	5810	1756	1269	5042	13877	3469.25
DIKE 3-WHTF	NUMBER	363	61	74	183	681	170.25
	WEIGHT	4772	581	770	3877	10000	2500
DIKE 1-LAKE	NUMBER	216	122	80	421	839	209.75
	WEIGHT	3195	2461	2003	4551	12210	3052.5
DIKE 3-LAKE	NUMBER	133	154	35	361	683	170.75
	WEIGHT	1143	1589	478	2846	6056	1514
LOWER LAKE	NUMBER	64	64	14	166	308	77
	WEIGHT	782	1767	306	919	3774	943.5
THURMAN ISLANE	NUMBER	70	32	19	301	422	105.5
	WEIGHT	13718	1533	299	4610	20160	5040
NORTH ANNA ARI	NUMBER	40	103	59	22	224	56
	WEIGHT	1450	14333	9344	5253	30380	7595
TOTAL NUMBER		1610	768	467	2381	5226	145.2
TOTAL WEIGHT		31656	27347	16539	29860	105402	2927.8

TABLE 3.3-3 ELECTROFISH SUMMARY 2000
ELECTROFISH - LAKE
STATION:ALL STATIONS

SPECIES	FEBRUARY NUMBER	FEBRUARY WEIGHT(g)	MAY NUMBER	MAY WEIGHT(g)	AUGUST NUMBER	AUGUST WEIGHT(g)	OCTOBER NUMBER	OCTOBER WEIGHT(g)	TOTALS NUMBER	TOTALS WEIGHT(g)	% OF TOTAL NUMBER	% OF TOTAL WEIGHT
L.macrochirus	396	4078	364	4059	119	1846	987	7126	1866	17110	75	24
N.hudsonius							156	922	156	922	6	1
L.auritus	33	2726	33	540	28	473	47	1008	141	4748	6	7
M.salmoides	58	11683	15	2977	15	2420	20	3989	108	21070	4	29
L.gulosus	13	179	16	269	11	283	15	201	55	932	2	1
L.microlophus	8	390	11	791	5	89	10	235	34	1505	1	2
D.cepedianum			3	466	19	2976	7	957	29	4399	1	6
L.cyanellus	5	45	8	161	1	21	13	105	27	332	1	0
P. nigromaculatus			11	1210	5	289	7	97	23	1596	1	2
C.analostana	6	13	1	3					7	15	0	0
N.procne							6	7	6	7	0	0
M.americana			6	217					6	217	0	0
C.carpio			3	10715	2	4000	1	3500	6	18215	0	25
P.flavescens					2	32	2	30	4	63	0	0
A.nebulosus			3	262					3	262	0	0
G.holbrooki	2	5							2	5	0	0
L.gibbosus			1	13					1	13	0	0
E.oblongus	1	1100							1	1100	0	2
A.catus	1	69							1	69	0	0
Total No.	523		475		207		1271		2476		100	
Total Wt.(g)	20288		21683		12430		18177		72579		100	

ELECTROFISH TOTALS - WHTF
STATION:ALL STATIONS

SPECIES	FEBRUARY NUMBER	FEBRUARY WEIGHT(g)	MAY NUMBER	MAY WEIGHT(g)	AUGUST NUMBER	AUGUST WEIGHT(g)	OCTOBER NUMBER	OCTOBER WEIGHT(g)	TOTALS NUMBER	TOTALS WEIGHT(g)	% OF TOTAL NUMBER	% OF TOTAL WEIGHT
L.macrochirus	1012	9286	241	2120	174	1124	1051	7971	2478	20501	90	62
L.cyanellus	19	163	8	125	49	1125	15	127	91	1539	3	5
M.salmoides	20	1087	10	664	15	121	9	1010	54	2882	2	9
L.microlophus	13	532	13	1387	3	40	13	180	42	2140	2	7
L.auritus	6	102	4	36	4	7	9	512	23	657	1	2
C.analostana	3	4	6	13	9	9			18	26	1	0
L.gulosus	3	58	7	204	3	66	4	37	17	365	1	1
I.punctatus	3	126	4	1115	1	415	1	17	9	1674	0	5
N.procne	8	11							8	11	0	0
A.catus							6	1802	6	1802	0	5
A.nebulosus							2	24	2	24	0	0
C.carpio					1	1200			1	1200	0	4
A.natalis					1	2			1	2	0	0
Total No.	1087		293		260		1110		2750		100	
Total Wt.(g)	11368		5664		4109		11681		32823		100	

TABLE 3.4-1 ESTIMATE OF HYDRILLA (Hydrilla verticillata) COLONIZATION OF LAKE ANNA and WHTF
North Anna Power Station 2000

	LAKE ANNA	WASTE HEAT TREATMENT FACILITY LAGOON 1	LAGOON 2	LAGOON 3	WHTF TOTAL
TOTAL ACRES	9600	225	2206	969	3400
AVAILABLE ACRES OF HABITAT(1)	3885	110	1158	442	1710
ACRES OF HYDRILLA COLONIZATION	65	3	16	10	29
PERCENT OF AVAILABLE HABITAT COLONIZED	2%	3 %	2%	2%	2%

(1) ACRES OF 15 FEET OR LESS WATER DEPTH

Table 4.1-1 Mean, maximum, and minimum hourly water temperatures (C) recorded in the North Anna River, at station NAR-1 by month, during 2000. Sample size (n) equals the number of hourly observations recorded each month.

	NAR-1			
Month	**Mean**	**Max**	**Min**	**n**
January	9.8	13.5	5.4	744
February	9.3	13.1	6.5	696
March	13.5	15.9	12.0	744
April	15.7	18.4	13.4	718
May	22.1	25.4	17.3	744
June	26.1	30.1	22.2	720
July	28.6	31.2	25.7	743
August	28.4	31.2	26.4	744
September	27.3	30.8	23.2	720
October	21.6	28.6	18.7	744
November	17.0	20.4	9.1	720
December	11.4	14.5	7.7	744

Table 4.3-1. Number and biomass (g) of fishes collected during May, August and September, 2000 electrofishing surveys of the North Anna River.

Family / Species	NAR-1		NAR-2		NAR-4		NAR-6		Total	
	Number	Total Weight	Number	Total Weight	Number	Total Weight	Number	Total Weight	Number	Total Weight
Petromyzontidae										
Petromyzon marinus							1	5	1	5
Anguillidae										
Anguilla rostrata	55	1304.1	14	432.5	8	94.5	12	281.5	89	2112.6
Cyprinidae										
Cyprinella analostana	4	9.6	2	17.8	7	22.7	4	18	17	68.1
Lythrurus ardens	16	41.7	1	1.3	84	135.1	6	8.6	107	186.7
Nocomis leptocephalus					3	24.0	1	3.0	4	27.0
Nocomis micropogon					7	118.9	3	68.1	10	187.0
Notropis amoenus	6	26.0					1	4.8	7	30.8
Notropis procne							2	2.9	2	2.9
Notropis rubellus			1	1.4	1	1.6	5	3.3	7	6.3
Semotilus corporalis	8	111.9	6	60.3	14	76.8	3	49.3	31	298.3
Catostomidae										
Erimyzon oblongus					1	16.2			1	16.2
Hypentelium nigricans	4	155.0	3	207.9			2	135.6	9	498.5
Ictaluridae										
Ameiurus natalis			4	9.5			2	2.7	6	12.2
Ameiurus nebulosus					1	17.3			1	17.3
Noturus gyrinus							4	17.1	4	17.1
Noturus insignis	36	167.5	9	16.5	6	29.4	8	75.0	59	288.4
Centrarchidae										
Lepomis auritus	98	1642.4	41	282.9	66	582.4	51	409.1	256	2916.8
Lepomis macrochirus	6	129.7	2	14.9			17	191.7	25	336.3
Micropterus dolomieu	1	6.8	2	288.0			1	12.0	4	306.8
Micropterus salmoides	1	512.8	4	61.3					5	574.1
Percidae										
Etheostoma olmstedi	2	5.1	3	3.8	5	7.3	3	3.6	13	19.8
Etheostoma vitreum			1	1.7			1	1.3	2	3.0
Percina peltata	15	54.8	11	17.8	1	3.8	1	2.9	28	79.3
Total	252	4167.4	104	1417.6	204	1130.0	128	1295.5	688	8010.5
Number of species	13		15		13		20		23	

TABLE 4.3-2. RAW CATCHES OF FISH BY GEAR TYPE IN THE NORTH ANNA RIVER FOR THE PERIOD 1990 - 2000.

YEAR	MAY BACKPACK	JULY BACKPACK	SEPTEMBER BACKPACK	BACKPACK STATIONS SAMPLED	BACKPACK TOTAL	MAY ELECTRIC SEINE	JULY ELECTRIC SEINE	SEPTEMBER ELECTRIC SEINE	ELECTRIC SEINE STATIONS SAMPLED	ELECTRIC SEINE TOTAL	ANNUAL TOTAL
1990	111	104	134	12	349	658	577	804	12	2039	2388
1991	77	148	120	12	345	1150	1285	715	12	3150	3495
1992	153	82	102	12	337	1179	422	570	12	2171	2508
1993	34	60	78	11	172	222	250	257	12	729	901
1994	63	88	145	12	296	271	276	228	12	775	1071
1995	*	*	116	4	116	*	*	291	4	291	407
1996	*	152	109	6	261	*	408	140	6	548	809
1997	114	111	131	12	356	617	184	510	12	1311	1667
1998	153	144	234	12	531	558	171	368	12	1097	1628
1999	319	215	242	12	776	598	283	601	12	1482	2258
2000	127	111	209	12	447	111	130	*	8	241	688

* INDICATES THAT NO SAMPLE WAS TAKEN

Table 4.3-3 Fishes collected from the North Anna River during annual electrofishing surveys, 1981-2000.

Family	Species	NAR-1	NAR-1	NAR-4	NAR-6
Petromyzontidae	*Lampetra appendix*		X	X	X
	Petromyzon marinus	X	X	X	X
Anguillidae	*Anguilla rostrata*	X	X	X	X
Clupeidae	*Alosa aestivalis*	X			
	Dorosoma cepedianum	X			
Esocidae	*Esox americanus*				X
	Esox niger	X	X	X	X
Cyprinidae	*Cyprinella analostana*	X	X	X	X
	Hyboganthus regius			X	X
	Luxilus comutus			X	
	Lythrurus ardens	X	X	X	X
	Nocomis leptocephalus	X	X	X	X
	Nocomis micropogon	X	X	X	X
	Notemigonuxc crysoleucas	X	X	X	X
	Notropis amoenus	X	X	X	X
	Notropis hudsonius				X
	Notropis procne	X	X	X	X
	Notropis rubellus	X	X	X	X
	Phoxinus oreas			X	
	Rhinichthys atratulus				X
	Semotilus corporalis	X	X	X	X
Catostomidae	*Catostomus commersoni*		X		X
	Erimyzon oblongus	X	X	X	
	Hypentelium nigricans	X	X	X	X
	Moxostoma macrolepidotum		X	X	X
Ictaluridae	*Ameriurus natalis*	X	X	X	X
	Ameriurus nebulosus	X	X		X
	Ictalurus punctatus				X
	Noturus gyrinus				X
	Noturus insignis	X	X	X	X
Aphredoderidae	*Aphredoderus sayanus*			X	X
Percichthyidae	*Morone americana*	X			
Centrarchidae	*Acantharchur pomotis*	X			
	Centrarchus macropterus				X
	Enneacanthus gloriosus				X
	Lepomis auritus	X	X	X	X
	Lepomis gibbosus	X	X	X	X
	Lepomis gulosus				X
	Lepomis macrochirus	X	X	X	X
	Lepomis microlophus	X	X		X
	Micropterus dolomieu	X		X	X
	Micropterus salmoides	X	X	X	X
	Pomoxis nigromaculatus	X	X	X	X
Percidae	*Etheostoma olmstedi*	X	X	X	X
	Etheostoma vitreum	X	X	X	X
	Perca flavescens	X			X
	Percina notograma		X	X	X
	Percina peltata	X	X	X	X
Soleidae	*Trinectes maculatus*				X

Table 4.3-4. Ranked abundance of species comprising greater than 80 percent of the pooled annual North Anna River electrofishing catch from all stations, 1981-2000. A species rank of 1 indicates it was the most abundant fish collected.

Species	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Notropis procne	2	1	1	1	1	1	1	1	1	4	2	3	1	2	7	3	2	2	4	--
Cyprinella analostana	1	2	2	3	2	2	5	2	3	2	1	1	3	6	6	1	1	4	2	--
Lepomis auritus	3	3	3	2	3	4	2	3	2	1	4	2	2	1	1	2	3	1	1	1
Notropis rubellus	--	5	8	8	10	3	3	4	4	3	3	5	4	3	5	--	8	6	--	--
Noturus insignis	8	--	--	--	6	5	4	6	7	6	5	6	5	4	3	--	4	7	6	4
Percina peltata	--	--	7	4	5	6	--	5	--	5	6	--	8	5	8	6	10	--	--	6
Anguilla rostrata	4	4	4	6	9	--	6	--	6	7	--	7	6	7	4	4	6	5	7	3
Lythrurus ardens	--	--	--	--	7	7	7	--	--	--	7	4	7	--	2	--	5	3	3	2
Nocomis micropogon	6	--	5	--	--	8	--	--	--	--	8	8	--	--	9	--	--	--	--	--
Nocomis leptocephalus	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Semotilus corporalis	--	--	9	--	4	9	--	--	--	--	--	--	--	--	--	--	9	--	5	5
Notropis amoenus	7	6	--	7	--	--	--	--	5	--	--	--	--	--	--	5	7	8	--	--
Hypentelium nigricans	--	--	--	--	8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Notemigonus crysoleucas	--	--	--	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pomoxis nigromaculatus	--	--	6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lepomis macrochirus	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7	--	--	--	--
Total number of species collected	26	27	29	31	31	29	32	30	18	25	25	29	25	25	22	20	24	28	28	23
Number of species accounting for >80%	8	6	9	7	10	9	7	6	7	7	8	8	8	7	9	7	10	8	7	6
Percent of electrofishing catch	83	82	81	83	83	83	80	82	80	80	84	83	83	85	82	82	84	80	82	83

*-- indicates species was not among those comprising greater than 80% of the electrofishing catch

Table 4.3-5 Station total numbers and weights for 1998-2000 in the North Anna River

	1998		1999		2000	
Station	**#**	**weight**	**#**	**weight**	**#**	**weight**
NAR-1	373	7138.6	624	7741.0	252	4167.0
NAR-2	635	3646.0	693	2476.0	104	1418.0
NAR-4	338	3448.0	609	3146.0	204	1130.0
NAR-6	283	2287.0	332	2212.0	128	1295.5

Table 4.4-1. Number of smallmouth bass and largemouth bass observed during North Anna River snorkel surveys conducted in 2000. Sample size (n) equals the number of times each count was performed in 2000.

				Smallmouth bass [1]			Largemouth bass [2]		
Station	Bank	Count	n	SMBYOY	SMB<11	SMB>11	LMBYOY	LMB<12	LMB>12
NAR-1	North	1	5	2	0	2	20	5	4
		2	4	1	0	0	24	3	1
		3	4	1	0	0	24	4	1
	South	1	5	9	0	0	8	4	6
		2	4	6	0	2	5	4	14
		3	4	4	1	2	7	2	6
NAR-2	North	1	5	7	0	0	3	3	3
		2	5	4	1	0	5	6	1
		3	5	4	2	0	2	3	1
	South	1	5	0	3	1	2	5	2
		2	5	1	2	2	8	4	2
		3	5	1	2	0	3	6	0
NAR-4	North	1	5	2	2	3	6	1	1
		2	5	6	1	1	6	2	4
		3	5	7	3	0	3	1	0
	South	1	5	7	6	1	0	2	0
		2	5	7	5	3	1	4	2
		3	5	6	2	1	2	2	2
NAR-5	North	1	5	3	17	7	0	3	3
		2	5	4	10	5	1	10	1
		3	5	2	8	7	0	4	6
	South	1	5	4	2	1	3	1	0
		2	5	3	1	1	3	1	0
		3	5	5	3	0	1	3	1

[1] SMYOY were less than or equal to 120 mm, SMB<11 were 121-279 mm, SMB>11 were larger than or equal to 280 mm TL.

[2] LMBYOY were less than or equal to 120 mm, LMB<11 were 121-304 mm, LMB>11 were larger than or equal to 305 mm TL.

Table 4.4-2. Cover use by smallmouth bass and largemouth bass in the North Anna River observed during the first of three counts made during snorkel surveys conducted in 2000.

	Cover Type				
NAR-1	Ledge	Boulder	Wood	Vegetation	Open*
SMBYOY**	0	2	3	5	2
SMB<11	0	0	0	0	0
SMB>11	0	0	0	2	0
LMBYOY	0	0	2	27	0
LMB<12	0	0	1	6	0
LMB>12	0	1	3	5	1
NAR-2	Ledge	Boulder	Wood	Vegetation	Open
SMBYOY	0	0	0	6	0
SMB<11	0	0	0	0	3
SMB>11	0	0	1	0	0
LMBYOY	0	0	1	3	1
LMB<12	0	0	1	4	3
LMB>12	0	0	1	1	3

	Cover Type				
NAR-4	Ledge	Boulder	Wood	Vegetation	Open
SMBYOY	0	6	0	3	0
SMB<11	0	7	0	1	0
SMB>11	0	3	0	1	0
LMBYOY	0	0	0	6	0
LMB<12	0	1	0	1	0
LMB>12	0	0	0	2	0
NAR-5	Ledge	Boulder	Wood	Vegetation	Open
SMBYOY	0	2	1	3	1
SMB<11	0	10	2	7	1
SMB>11	0	1	6	1	0
LMBYOY	0	1	0	1	1
LMB<12	0	1	1	1	0
LMB>12	0	0	4	0	0

*Fish observed in open water were farther than 0.5 m from any cover type.
**See Table 4.3-1 for size category definitions.

Table 4.4-3. Cover use by smallmouth bass and largemouth bass in the North Anna River observed during the first of three counts made during snorkel surveys conducted in 2000. Data for observations at all stations are pooled.

	Cover Type				
All Stations	**Ledge**	**Boulder**	**Wood**	**Vegetation**	**Open**
SMBYOY	0	1	3	2	0
SMB<11	0	2	3	1	5
SMB>11	1	2	0	0	0
LMBYOY	0	0	5	15	2
LMB<12	0	1	6	7	4
LMB>12	0	0	10	6	3

na/xl/04/06/98

5.0 Literature Cited

Barko, J. W., D. G. Hardin, and M. S. Matthews. 1982. Growth and morphology of submerged freshwater macrophytes in relation to light and temperature. Canadian Journal of Botany, 60.6: 877-887. 1982.

Bettoli, P. W., M. J. Maceinia, R. L. Noble, R. K. Betsill. 1992. Piscivory in largemouth bass as a function of aquatic vegetation abundance. North American Journal of Fisheries Management. 12: 509-516, 1992.

Colle, D. E., and J. V. Shireman. 1980. Coefficients of condition for largemouth bass, bluegill, and redear sunfish in hydrilla-infested lakes. Transactions of the American Fisheries Society. 109: 521-531.

Hollander, M., and D.A. Wolfe. 1973. Non-parametric Statistical Methods. John Wiley and Sons, Inc., New York, New York.

Groshens, T.P., and D.J. Orth. 1995. Assessment of the transferability of habitat suitability criteria for smallmouth bass, Micropterus dolomieu. Environmental Biology of Fishes in press.

Jager, H.I., D.L. DeAngelis, M.J. Sale, W. Van Winkle, D.D. Schmoyer, M.J. Sabo, D.J. Orth, and J.A. Lukas. 1993. An individual-based model for smallmouth bass reproduction and young-of-year dynamics in streams. Rivers: Studies in the Science, Environmental Policy and Law of Instream Flow 4:91-113.

King, M.A., R.J. Graham, and W.S. Woolcott. 1991. Comparison of growth of smallmouth bass from two tributaries of the York River, Virginia. Pages 6-13 in D.C. Jackson, editor. The First International Smallmouth Bass Symposium. Mississippi State University Press, Mississippi State, Mississippi.

Lukas, J.A. 1993. Factors affecting reproductive success of smallmouth bass and redbreast sunfish in the North Anna River, Virginia. Master of Science thesis. Virginia Tech, Blacksburg, Virginia.

Lukas, J.A., and D.J. Orth. 1993. Reproductive ecology of redbreast sunfish Lepomis auritus in a Virginia stream. Journal of Freshwater Ecology 8:235-244.

Matthews, W.J. 1982. Small fish community structure in Ozark streams: structural assemblage patterns or random abundance of species? American Midland Naturalist 107(1):42-54.

Sabo, M.J. 1993. Microhabitat use and its effect on growth of age-0 smallmouth bass in the North Anna River, Virginia. Doctoral dissertation. Virginia Tech, Blacksburg, Virginia.

Sabo, M.J., and D.J. Orth. 1995a. Temporal variation in microhabitat use by age-0 smallmouth bass in the North Anna River. Transactions of the American Fisheries Society. In press.

Sabo, M.J., and D.J. Orth. 1995b. Effects of early growth rate on growth and survival of age-o smallmouth bass (Micropterus dolomieu Lacepede). Ecology of Freshwater Fish. In press.

Sabo, M.J., and D.J. Orth. 1995c. Net rate of energy gain by age-0 smallmouth bass foraging in different microhabitats within the North Anna River, Virginia. Environmental Biology of Fishes. In press.

Virginia Power. 1986. Section 316(a) demonstration for North Anna Power Station. Virginia Power, Richmond, Virginia.

Virginia Power. 1990. Environmental study of Lake Anna and the lower North Anna River. Annual report for calendar year 1989. Virginia Power, Richmond, Virginia.

Virginia Power. 1992. Environmental study of Lake Anna and the lower North Anna River. Annual report for calendar year 1991, including summary of 1989-1991, Lake Anna and the lower North Anna River. Virginia Power, Richmond, Virginia.

Virginia Power. 1993. Annual report for 1992: Lake Anna and the lower North Anna River. Annual report for calendar year 1992. Virginia Power, Richmond, Virginia.

Virginia Power. 1995. Annual report for 1994: Lake Anna and the lower North Anna River. Annual report for calendar year 1994. Virginia Power, Richmond, Virginia.

Virginia Power. 1996. Annual report for 1995: Lake Anna and the lower North Anna River. Annual report for calendar year 1995. Virginia Power, Richmond, Virginia.

Wrenn, W. B., D. R. Lowery, M. J. Maceina, and W. C. Reeves. 1995. Relationships between largemouth bass and aquatic plants in Guntersville Reservoir Alabama. Third National Reservoir Symposium, Chattanooga, Tennessee. 1995.